Reg. U. S. Pat. Off.

EXECUTIVE COMMITTEE

President
DEAN HARVEY

Vice-Presidents
P. H. BATES — J. R. TOWNSEND

Secretary-Treasurer
C. L. WARWICK

Members of Executive Committee
R. P. ANDERSON — ALEXANDER FOSTER, JR.
M. H. BIGELOW — L. H. FRY
T. A. BOYD — E. W. MCMULLEN
W. H. FINKELDEY — E. O. RHODES
J. H. FOOTE — F. G. TATNALL

Past-Presidents
W. M. BARR — G. E. F. LUNDELL
H. J. BALL

COMMITTEE ON PAPERS AND PUBLICATIONS

This committee has authority in all matters affecting the acceptance, rejection, editing and publication of papers, committee reports, and discussions. The committee also acts in an advisory capacity to the Executive Committee in publication matters in general.

C. L. WARWICK, *Chairman*
L. M. CURRIE — H. J. GILKEY
J. R. FREEMAN, JR. — C. E. HEUSSNER
W. H. GARDNER — E. F. KELLEY
J. C. GENIESSE — P. G. MCVETTY
H. S. RAWDON

Correspondent Members from Pacific Coast District
F. J. CONVERSE — R. E. DAVIS

ADMINISTRATIVE AND EDITORIAL STAFF

C. L. WARWICK
Secretary-Treasurer
J. K. RITTENHOUSE — *Assistant Treasurer*
R. E. HESS — *Assistant Secretary*
P. J. SMITH — *Standards Editor*
R. J. PAINTER — *Assistant to the Secretary*
G. A. WILSON
Assistant Editor

ASTM BULLETIN

Published by
AMERICAN SOCIETY for TESTING MATERIALS

This Issue Contains

New Actions on A.S.T.M. Standards 9

Determining the Flash Points of Heavy-Bodied Paints by the Tag Closed Cup and the Pensky-Martens Testers, *by David Busker* 13

Discussion of Paper on Behavior of Glazing Material Subjected to Explosion 15

New Steel Limitation Orders 18

Comparison of Methods for Determining the Drying Rates of Varnishes, *by Howard R. Moore* 19

A Method for Evaluating Performance in Service of Slow-Curing Asphalts, *by Joseph Zapata* . . . 31

Program of Activities of Committee D-19 on Water for Industrial Uses 40

Effects of Minor Alloying Elements on Aluminum Casting Alloys — Part II — Aluminum-Silicon Alloys, *by Walter Bonsack* 41

Masthead:
Materials Inspectors; President's Message 52

Miscellaneous Society Notes 53–55

XXXIII—Long-Time Society Committee Members 56

Comments from Forty-Year Members 57

New Members; Personals; Necrology 58–60

Complete List of Emergency Specifications and Emergency Alternates (Pink Slips) 61, 62

Index to Advertisers 62

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, October 1943. Published six times a year, January, March, May, August, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 260 S. Broad St., Philadelphia 2, Pa. Subscription $1.50 a year in United States and possessions, $1.75 in Canada, $2.00 in foreign countries. Single Copies—25 cents. Number 124. Entered as second class matter April 8, 1940, at the post office at Easton, Pa., under the act of March 3, 1879.

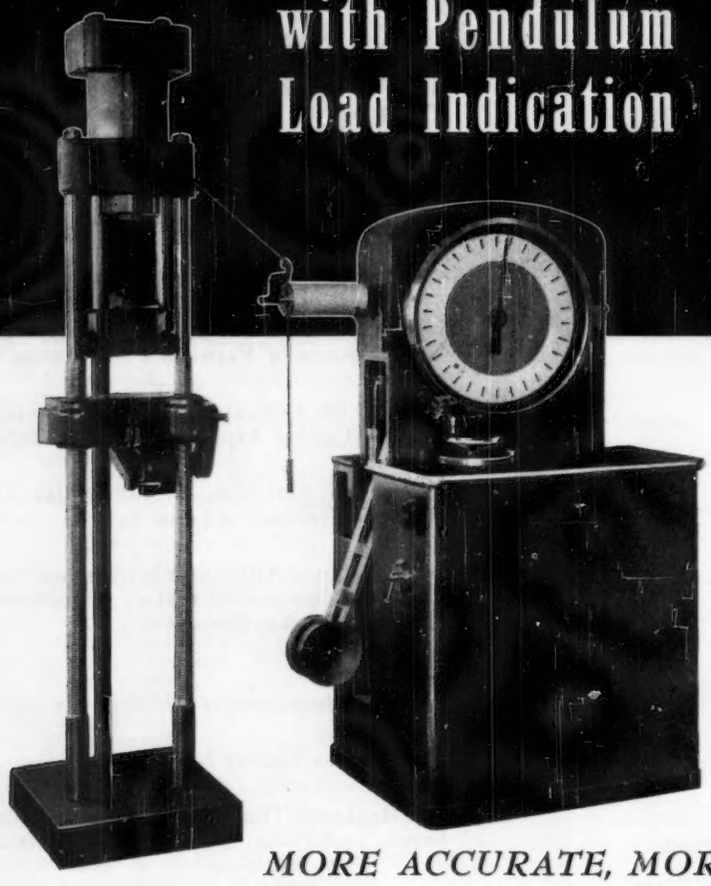
Copyrighted, 1943, by the American Society for Testing Materials.

OCTOBER—1943

No. 124

PRECISION HYDRAULIC TESTING MACHINE

with Pendulum Load Indication



VISIT RIEHLE DISPLAY . . .

Room 848, Palmer House, National Metal Congress War Conference Display, Oct. 18–22

MORE ACCURATE, MORE DEPENDABLE FOR PRODUCTION TESTING ***because:***

Pendulum load indicator operates on the natural laws of gravitation. ...This principle of operation is not affected by temperature changes or subject to metal fatigue....*Write for descriptive literature and quotations.*

ARMY E NAVY

RIEHLE

TESTING MACHINES

Division of
American Machine and Metals, Inc., East Moline, Illinois

Other Products: IMPACT TESTERS · VICKERS HARDNESS MACHINES · BRINNELL HARDNESS TESTERS · MEASURING INSTRUMENTS

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 R. E. Hess, Editor CABLE ADDRESS—TESTING

R. J. Painter, Associate Editor

Number 124 October 1943

New Actions on A.S.T.M. Standards

Standards Committee Approves New Specifications and Revisions Involving Steel, Stainless Steels, Electrical Resistance Alloys, Paints, Petroleum, Rubber, Soaps, and Plastics

MANY IMPORTANT actions on standards were taken by Committee E-10 on Standards at its meeting at A.S.T.M. Headquarters on August 30, and the committee also had previously approved by letter several important new standards. The number of new specifications and tests including emergency standards totals 18, while 24 standard and tentative specifications were involved in regular and emergency revisions approved by the committee. Of particular significance to the various industrial groups are the following: Comparison test for color of Army motor fuel; three new specifications covering clad plate (stainless sheets bonded to steel plates); several specifications for non-rigid plastics of various compositions; the new hardness conversion tables for steel; and two new emergency specifications for insulated wire and cable with synthetic rubber compound.

Notes on these new standards and various other actions appear below. The accompanying table gives a complete list of recent actions by Committee E-10.

Metals

Steel.—Through the work of a special group in its Section on Indentation Hardness, A.S.T.M. Committee E-1 on Methods of Testing completed the new Tentative Hardness Conversion Tables for Steels (E 48 – 43T) giving relationship between diamond pyramid hardness, Rockwell hardness, and Brinell hardness. The tables are based on extensive tests on carbon and alloy steels, mostly in the heat-treated condition, but have been found to be reliable on practically all constructional alloy and tool steels in the as-forged, annealed, normalized, and quenched-and-tempered conditions, provided they are homogeneous. Such special cases as high manganese steel, 18 per cent chromium, 8 per cent nickel steels, and other austenitic steels, nickel-base alloys as well as constructional alloy and tool steels in the cold-worked condition, may not conform to these relationships with the same degree of accuracy as the steels for which they are intended.

This is the second standard giving conversion tables developed by the special committee under the chairmanship of R. L. Kenyon; the first covered cartridge brass, E 33 – 42. The new tables covering steel are the result of cooperative efforts with the Society of Automotive Engineers and American Society for Metals.

Committee A-1 on Steel recommended emergency alternate provisions in two of its plate specifications, A 89 and A 70 (low tensile strength carbon plates of flange and firebox quality and carbon-steel plates for boilers and other pressure vessels) which provide slight increase in sulfur and in A 70 a higher tensile range, taking cognizance of the difficulty in obtaining melting stock and fuel low in sulfur.

An interesting emergency action involving electric-resistance-welded heat-exchanger and condenser tubes, EA - A 214, will permit the use of an electric tester in lieu of the hydrostatic test, and also in the interest of increased production the consumer may permit unnormalized material with consequent modifications in the flattening and hardness test. The electrical tester which can detect small defects which either partly or completely penetrate the tube wall was developed by Republic Steel Corp., Steel and Tube Division, using a basic Sperry process. Large amounts of the tubing inspected by the electric tester have been fabricated.

Stainless Steels.—Through a special subcommittee headed by D. B. Rossheim, Committee A-10 on Iron-Chromium-Nickel and Related Alloys completed three new tentative specifications for clad sheet, strip, and plate as follows: (*a*) corrosion-resisting chromium steel; (*b*) corrosion-resisting chromium nickel; and (*c*) nickel and nickel-base alloy. The Boiler Code Committee had desired standards for these materials used in construction of vessels subject to code rulings, and so that recognized requirements could cover material for other uses the special subcommittee had been organized and after intensive work agreement was reached. This clad material involves plate of a carbon or low-alloy base steel to which is continuously bonded on one or both sides a layer of the stainless material. Thus material may be single clad or double clad product. In the specifications the types of stainless material are covered by reference to other A.S.T.M. specifications. For example, in the nickel and nickel-base standard, the cladding metal must conform to nickel, nickel-copper, or nickel-chromium-iron alloys established by committees functioning in the non-ferrous metals field. Tests include tensile and bend tests. The physical properties as determined by tensile test are to equal the minimum requirements for the base steel specifications. On the thinner material the test specimen is the complete thickness, where on the thicker

material the standard 1/2-in. round tension test specimen can be used providing the ratio of clad material to base material is maintained.

Minor changes in emergency provisions EA – A 167 and EA – A 240 were approved as a result of changes in the respective standards, these materials covering corrosion-resistant, chromium-nickel plate sheet, and related material, the latter used for fusion-welded unfired vessels.

Magnetic Properties.—Essentially the revisions in the three tentative test methods approved on the recommendation of Committee A-6 on Magnetic Properties and the tentative revision of the *Standard* Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 42) are to provide modified or additional procedures which can be tried out before the methods are adopted as standard. One action involved the incorporation in the test for incremental permeability and core loss of flat-rolled magnetic materials (A 258) of the requirements on alternating current tests at low inductions covered in the general tests for magnetic properties A 34. The new test will be entitled "Normal and Incremental Permeability and Core Loss of Flat-Rolled Magnetic Materials at Low Alternating Inductions, using 28-cm. Specimens."

A modification in the test for permeability of feebly magnetic materials (A 259) comprised the addition of a third test method. In the tentative test (A 257) covering permeability and core loss of flat materials a note is being added in relation to strain-sensitive materials indicating that clamping should not be used and that care should be taken to reduce sagging and strains in the center portion of the strip.

Non-Metallic Materials

Paint Materials.—Of the two new specifications approved on the recommendation of Committee D-1 the first covers red and brown iron oxide pigments which supersedes a standard that covered mineral iron oxide (D 84), and the second gives new requirements for methyl ethyl ketone, thus adding another to the several solvents covered by A.S.T.M. specifications. Three classes of iron oxides are covered in the first-named specification: those considered commercially pure; those containing from 70 to 97 per cent iron oxide and those with lower percentages, 40 to 70. The new solvent specification gives requirements on specific gravity, color, odor, acidity, etc.

Another action developed by Committee D-1 was the addition of two grades, E and F, in the specifications for orange shellac and other lacs which standard has been reverted to "tentative." New Grade E usually occurs in the form of circular disks and is known as pure button lac, while Grade F is dark garnet in color. It sometimes is manufactured in admixture with rosin and as a dewaxed lac.

Waterproofing and Roofing Materials.—The difficulty of obtaining condensers constructed of block tin has resulted in emergency provisions in the test for bituminous mastics, grouts, and like mixtures, EA – D 147, covering a tinned copper apparatus with a glass condenser. Committee D-8 also through emergency provisions EA – D 228 in the test for asphalt roofing, cap sheets, and shingles is bringing certain requirements in line with Limitation Order L 228. Emergency provision for roofing surfaced with powdered talc or mica (EA – D 224) permits reduction of the 60-lb. dry felt classified as Type 1, Grade A, to a 58-lb. minimum, in accordance with order L 228, and the revised emergency provision EA – D 249a, roofing surfaced with coarse mineral granules, will permit a 4-in. selvage edge.

Petroleum Products.—The new emergency method of test for color of U. S. Army motor fuel by means of an A.S.T.M. color standard ES – 32, exemplifies the willingness of the Society and its committees to work closely with the Government services and also is an example of the promptness with which the Society can move to provide an urgently needed standard. This new method, which incidentally involves the marketing of a sample was requested by the Specifications Branch of the Army which needed a rapid procedure for determining whether motor fuel color conformed to the requirements in the Army Specifications No. 2-103. The color standard developed through the intensive work of H. M. Hancock, chairman of Committee D-2's Subcommittee VI on Color, is a 4-oz. sample bottle with an aqueous solution of inorganic salts. The colorimetric characteristics are carefully specified and the National Bureau of Standards certifies the color of each batch of material.

The color standard with a copy of the printed emergency method can be obtained at 85 cents each from A.S.T.M. Headquarters, which charge is intended to cover the cost to the Society of furnishing the material.

Electrical Insulating Materials.—Since there was need for a standard method of measuring dimensions of rigid rods used in electrical insulation, a new tentative method, D 741, was developed. It is similar to a companion method for measuring dimensions of rigid tubes (D 668 – 42 T).

Rubber Products.—On August 13, Committee E-10 by letter action accepted two new emergency specifications covering insulated wire and cable ES – 33 and ES – 34. These standards were expedited by Committee D-11 since a limitation order effective after August 15 would have prevented the use of crude rubber in the manufacture of insulation or jacket compound, and synthetic and reclaimed rubber has to replace crude rubber for these particular requirements. Earlier, Committee D-11 had developed emergency specifications for chloroprene sheath compound (ES 28 and ES 30), and at the June Annual Meeting there were approved new specifications for polyvinyl insulating compound (D 734). The new specifications which permit the use of a compound known as Government Rubber, Type GR-S, are now available for industry guidance and performance references in WPB orders.

While other A.S.T.M. specifications are being continued as references in WPB order R-1, they are for certain uses of the armed forces only. Commercial users and many land installations of Government forces will use the new specifications. Prompt development of these standards was handled through D-11's Subcommittee V on Insulated Wire and Cable headed by R. A. Schatzel, who also is chairman of the Technical Advisory Committee, Rubber and Rubber Products Division, WPB. In each specification the insulation must have a minimum tensile strength of 700 psi. and elongation at rupture of 300 min. The performance compound (ES 34) must not show depreciation in tensile strength and elongation of more than 35 per cent after 96 hr. in the oxygen pressure test,

while the heat-resisting compound (ES 33) must not show more than 50 per cent depreciation after 20 hr. air pressure heat test or after 168 hr. at 80 C. in oxygen pressure test.

Soaps.—The emergency provisions in the specifications for chip soap (EA – D 469) and for powdered soap (nonalkaline soap powder) (EA – D 490) by permitting the use of rosin to a maximum of 10 per cent will increase the supply of fats for soap, although this provision will not be resorted to except in case the present shortage of fats grows more acute, in which case it was felt desirable to have the provision available. With the permissible rosin, the titer of the mixed fatty acids prepared from soap can be reduced from 39 to 36 C.

Soils.—In the Standard Method of Mechanical Analysis of Soils (D 442 – 39) which covers a procedure for determining quantitatively the distribution of particle sizes, certain hydrometers are used, and in order to permit use of streamlined bulb hydrometers a tentative modification has been approved which gives requirements on the graduation (graduations are in grams of soil per liter of suspension).

Plastics.—The latest in the series of important specifications and tests for plastics developed through the intensive work of Committee D-20 covers so-called nonrigid type of plastics. The six tentative standards approved by Committee E-10 cover the following:

Nonrigid Polyvinyl Chloride-Acetate Plastics (D 742 – 43 T)
Nonrigid Ethyl Cellulose Plastics (D 743 – 43 T)
Nonrigid Polyvinyl Chloride Plastics (D 744 – 43 T)
Nonrigid Polyvinyl-Butyral Plastics (D 745 – 43 T)
Tentative Method of Test for Stiffness in Flexure of Nonrigid Plastics (D 747 – 43 T)
Tentative Method of Test for Brittleness of Nonrigid Plastics (D 746 – 43 T)

In addition to these new tentative standards, there were approved several modifications in specifications approved earlier this year. In the case of polystyrene molding compounds (D 703) a new type 3 material has been added which is a general purpose molding material characterized by superior heat-resistant qualities.

The new specification for polyvinyl chloride (D 742) covers two types of transparent and opaque material which have approximately a 95 per cent vinyl chloride content. Type 1 is unfilled while type 2 contains an inert filler. There are five grades of material. Type 1 has tensile strength ranges from 1000 to 3000 psi. and the three grades in type 2 have a tensile range of 600 to 1200 psi. Various properties are specified which can be determined according to A.S.T.M. tests that are cited, including the two new tests for stiffness and brittleness.

The two types of ethyl cellulose (D 743) are divided into three grades: filled, unfilled, and temperature resistant.

The three types of polyvinyl plastics provided for in D 744 are for general purpose, heat and oil resistance, and cold resistance. Nine grades of material are included.

The polyvinyl butyral plastics are of thermoplastic and curing types. The materials are based on polyvinyl butyral resin, obtained by the partial acetalization with butyraldehyde of the product obtained by the complete or partial hydrolysis of polyvinyl acetate. Plasticizers, coloring agents, modifying agents, etc., can be incorporated as may be necessary to obtain the desired properties. There are seven grades of material, three thermoplastic and four of the curing type. Although the hardness serves as a general indication of grade in most cases, the hardness range of one grade suitable for a given application will overlap the hardness range of another grade. The low temperature classification as determined by the brittleness test (thiokol test) (D 736 – 43 T) also serves in classifying the various grades.

It was indicated in the new method for stiffness in flexure that the procedure is well suited for determining flexibility over a wide range. The apparatus is of the cantilever beam bending type of which the Olsen Stiffness Tester (Tour-Marshall and Olsen Design) is an example.

The test for brittleness of nonrigid plastics (D 746) establishes a temperature above which a normally nonrigid material is not brittle in its reaction to sudden deformation. The test uses an apparatus with a striking arm which moves at a designated rate. Beginning with the lowest temperature (−70 C. or at least lower than the temperature at which non-failure is thought to be) specimens are tested at 10 deg. temperature intervals until a break is obtained. Tests are repeated until five consecutive cases of non-breaking are observed. Coolant used in the bath may be acetone, ethyl alcohol, butyl alcohol, etc. For very low temperatures liquid nitrogen is considered suitable.

Spectrographic Analysis.—Two new tentative methods developed through the work of Committee E-2 on Spectrographic Analysis cover Tentative Spectrochemical Method for the Determination of Impurities in Tin Alloys (E 51 – 43 T) and Tentative Spectrochemical Method for the Determination of Impurities in Lead Alloys (E 49 – 43 T). These new methods will provide the analyst with rapid methods for investigating the various alloys of lead and tin, particularly those compositions covered by A.S.T.M. specifications.

The method involving lead alloys gives a procedure for the determination of 0.001 to 0.30 per cent of antimony, arsenic, barium, bismuth, copper, iron, magnesium, nickel, silver, strontium, tin, and zinc in lead, lead-calcium, and lead-antimony alloys, with an average precision of ± 10 per cent of the amount of the element sought. It is also applicable to other alloys of high lead content except those containing a large proportion of tin.

The average time per determination depends somewhat on how many elements are sought. Where six or more elements are sought, about 30 minutes should be allowed for the determination of each element in triplicate. This time includes that spent in preparation of the samples, arcing samples and standards, photographing spectra, processing and reading the plate.

The method for tin alloys (E 51) covers the determination of 0.001 to 1.0 per cent of antimony, and 0.001 to 0.3 per cent of aluminum, arsenic, bismuth, copper, iron, lead, nickel and zinc in solders, bronzes, tin base die-cast alloys and other alloys high in tin.

An additional procedure making use of photometric measurement has been included in the Tentative Method of Quantitative Spectrochemical Analysis of Zinc Alloy

ACTIONS BY COMMITTEE E-10 ON STANDARDS

Unless noted all actions approved at Committee E-10 meeting on August 30, 1943.

NEW TENTATIVE AND EMERGENCY STANDARDS

Ferrous Metals

Specifications for (*Committee A-10*):

Corrosion-Resisting Chromium Steel Clad Plate, Sheet, and Strip (A 263–43 T).
Corrosion-Resisting Chromium-Nickel Steel Clad Plate, Sheet, and Strip (A 264 – 43 T).
Nickel and Nickel-Base Alloy Clad Steel Plate (A 265 – 43 T).

Paint, Varnish, Lacquer, and Related Products

Specifications for (*Committee D-1*):

Red and Brown Iron Oxide (D 84 – 43 T), superseding Standard Specifications D 84 – 41.
Methyl Ethyl Ketone (D 740 – 43 T).

Petroleum Products and Lubricants

Emergency Method of (*Committee D-2*):

Test for Color of U. S. Army Motor Fuel (All-Purpose) by Means of an A.S.T.M. Color Standard (ES – 32) (August 24.)

Electrical Insulating Materials

Methods of (*Committee D-9*):

Measuring Dimensions of Rigid Rods Used in Electrical Insulation (D 741 – 43 T).

Rubber Products

Emergency Specifications for (*Committee D-11*):

Insulated Wire and Cable Heat Resisting Synthetic Rubber Compound (ES – 33). (August 13.)
Insulated Wire and Cable Performance Synthetic Rubber Compound (ES – 34). (August 13.)

Plastics

Specifications for (*Committee D-20*):

Nonrigid Vinyl Chloride-Acetate Plastics (D 742 – 43 T).
Nonrigid Ethyl Cellulose Plastics (D 743 – 43 T).
Nonrigid Vinyl Chloride Plastics (D 744 – 43 T).
Nonrigid Vinyl Butyral Plastics (D 745 – 43 T). (Sept. 7.)

Methods of (*Committee D-20*):

Test for Brittleness of Nonrigid Plastics (D 746 – 43 T).
Test for Stiffness in Flexure of Nonrigid Plastics (D 747 – 43 T).

Methods of Testing

(*Committee E-1*):

Hardness Conversion Tables for Steel (Relationship Between Diamond Pyramid Hardness, Rockwell Hardness, and Brinell Hardness (E 48 – 43 T). (August 24.)

Spectrographic Analysis

Methods of (*Committee E-2*):

Spectrochemical Analysis for Impurities in Lead Alloys (E 49 – 43 T).
Spectrochemical Analysis for Impurities in Tin Alloys (E 51 – 43 T).

REVISIONS IN EXISTING TENTATIVE STANDARDS

(Incorporated Immediately)

Standard Specifications for:

Orange Shellac (D 237 – 41), and reversion to tentative.

Tentative Specifications for:

Polystyrene Molding Compounds (D 703 – 43 T).
Cellulose Acetate Molding Compound (D 706 – 43 T).
Cellulose Acetate Butyrate Molding Compound (D 707 – 43 T).

Tentative Methods of:

Test for Permeability and Core Loss of Flat-Rolled Magnetic Materials Using 28-cm. Specimen (A 257 – 43 T).
Test for Incremental Permeability and Core Loss of Flat-Rolled Magnetic Materials at Low Alternating Inductions Using 28-cm. Specimen (A 258 – 43 T).
Test for Permeability of Feebly Magnetic Materials (A 259 – 43 T).
Test for Impact Resistance of Plastics and Electrical Insulating Materials (D 256 – 43 T). (Sept. 24.)
Quantitative Spectrochemical Analysis of Zinc for Lead, Iron, and Cadmium (E 26 – 43 T).
Quantitative Spectrochemical Analysis of Zinc Alloy Die Castings for Minor Constituents and Impurities (E 27 – 43 T).

TENTATIVE REVISIONS OF STANDARDS

(Not incorporated, but published for comment)

Standard Methods of:

Test for Magnetic Properties of Iron and Steel (A 34 – 42).
Testing Sheet and Plate Materials Used in Electrical Insulation (D 229 – 42).
Mechanical Analysis of Soils (D 422 – 39).

Emergency Alternate Provisions in

Tentative Specifications for:

Asphalt Roofing Surfaced with Powdered Talc or Mica (EA – D 224a).
Asphalt Roofing Surfaced with Coarse Mineral Granules (EA – D 249a).

Standard Specifications for:

Carbon-Steel Plates for Stationary Boilers and Other Pressure Vessels (EA – A 70).
Low Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities (EA – A 89).
Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes (EA – A 214a).
Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip (EA – A 167a).
Corrosion-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels (EA – A 240a).
Chip Soap (EA – D 496).
Powdered Soap (Nonalkaline Soap Powder) (EA – D 498).

Tentative Methods of:

Testing Asphalt Roll Roofing, Cap Sheets, and Shingles (EA – D 228).

Standard Methods of:

Testing Bituminous Mastics, Grouts, and Like Mixtures (EA – D 147).

Die Castings for Minor Constituents and Impurities (E 27 – 40 T).

The revised Methods of Test for Quantitative Spectrochemical Analysis of Zinc for Lead, Iron, and Cadmium (E 26 – 43 T) may be applied to any grade of zinc providing the lead, iron, and cadmium contents are less than 0.1 per cent. An arc spectrum is used, employing graphite electrodes, one of which is treated with a solution of the sample to be analyzed. Quantitative estimations are made by the comparison of the spectrum of the sample with the spectra of standard samples of known composition.

Determining the Flash Points of Heavy-Bodied Paints by the Tag Closed Cup and the Pensky-Martens Testers

By David Busker[1]

EDITOR'S NOTE.—This paper presents the results of a study carried on at the National Bureau of Standards to determine the flash points of heavy-bodied paints by the Tag closed cup and Pensky-Martens Testers. The Army Specification T-1279B (Camouflage Oleoresinous Paint) requiring the determination of flash points by the Pensky-Martens instrument is a direct result of the research contained in this paper.

THE DETERMINATION of flash points by the Tag closed cup tester is prescribed in many specifications for paints, for example, in War Engineers' Specification T-1279 covering a thick-bodied camouflage paint of the emulsifiable type. Since there is no means of stirring the paint while it is being tested in the Tag closed cup tester, the significance of the results has been questioned, particularly in the case of heavy-bodied viscous paints.

The scope of the Tag closed cup tester is defined in A.S.T.M. Standard Method of Test for Flash Point by Means of the Tag Closed Tester (D 56 – 36),[2] as follows:

(*a*) This method of test is intended for determining the flash point of all mobile liquids flashing below 175 F. (79 C.), with the exception of products classed as fuel oil which are preferably tested with the A.S.T.M. Pensky-Martens closed tester.
(*b*) Provision is made in Sections 7 and 8 of this method for determining the flash point of lacquer solvents or diluents of low flash points.

The scope of the Pensky-Martens tester is defined in A.S.T.M. Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 42)[3] as follows:

(*a*) This method of test is intended for determining the flash point of fuel oils unless the use of the Tag closed tester is specified.
(*b*) Provision is made in Sections 7 to 9 of this method for determining the flash point of cut-back asphalts and other viscous materials and suspensions of solids.

These descriptions of the fields of application of the two testers, both of which are completely described in A.S.T.M. Methods D56[2] and D93,[3] leave some uncertainty as to the one more suitable for heavy-bodied paints containing highly volatile vehicles and to the relation between the results to be expected from the two instruments. It is the purpose of this paper to clear up this uncertainty.

The most important difference between the two testers is that the liquid is mechanically stirred (approximately 110 rpm.) in the Pensky-Martens tester but not in the Tag closed cup tester. Another difference is in the prescribed rate of heating, 1.6 to 2.0 F. per min. in the Tag closed cup tester and 9 to 11 F. per min. in the Pensky-Martens tester when testing fuel oil and 4 to 6 F. per min. when testing "viscous materials and suspensions of solids." In order to differentiate the effects of stirring from those involved in the different rates of heating, it was decided to heat the material in the two instruments at the rate prescribed for the Tag closed cup tester, 1.6 to 2.0 F. per min. To do this, it was necessary to substitute a smaller burner under the Pensky-Martens tester. In Table I are shown the flash points of a number of samples of paint observed under the conditions stated.

TABLE I.—COMPARISON OF FLASH POINTS OBTAINED BY THE TAG CLOSED CUP AND PENSKY-MARTENS TESTERS ON DIFFERENT SAMPLES OF CAMOUFLAGE PAINT.

Sample	Temperature, deg. Fahr.	
	Tag Closed Cup Tester	Pensky-Martens Tester (Two Determinations)
A.....	83	89 91
B.....	82	93 95
C.....	96	107 109
D.....	94	105 106
E.....	96	106 106

It is evident that, with materials of this type, the Pensky-Martens tester gives flash points from 6 to 13 F. higher than the Tag closed cup tester. It also appears that good agreement between duplicate tests can be obtained with the Pensky-Martens tester.

Next, the flask points of some volatile solvents and of paints made by adding these solvents to pigment pastes were observed by the use of both instruments. The materials used in this series of tests were as follows:

Sample F.—Varsol (Esso) was used as a representative solvent of low viscosity.

Sample G.—A mixture of Varsol and low-flash naphtha (V. M. and P.) in the ratio of 16 parts to 1 by volume was selected to represent a blended solvent composed of materials of greatly different volatilities.

Sample H.—Using Varsol as a thinner for an iron oxide paste-in-oil, a paint was prepared which had approximately the same consistency as that of the camouflage paints. This required 305 g. of paste to 60 ml. of Varsol.

Sample I.—A similar paint was prepared from the same proportions of paste and thinner used in sample *G*.

The flash points of these materials observed with both testers are given in Table II.

TABLE II.—FLASH POINTS OF EXPERIMENTAL MATERIALS.

Sample	Temperature, deg. Fahr.		
	Tag Closed Cup Tester	Water Bath in Tag Closed Cup Tester	Pensky-Martens Tester
F.....	95	.....	94
G.....	89 90	.....	89 90
H.....	98 99	124	110 112
I.....	90	.....	105

It appears from these results that both testers give the same flash point of a mobile liquid, but that there is again a difference of 12 to 15 F. in the observed flash points of a

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] Chemist, National Bureau of Standards, Washington, D. C.

[2] 1942 Book of A.S.T.M. Standards, Part III, p. 163.

[3] *Ibid.*, p. 157.

fairly viscous paint. The obvious explanation is that in the Tag closed cup tester the unstirred paint in direct contact with the cup becomes hot enough to produce the vapor required for a flash while the center of the mass around the thermometer is still relatively cool. The well-stirred material in the Pensky-Martens tester is kept at a fairly uniform temperature which is correctly represented by the thermometer.

There was some uncertainty as to the uniformity of temperature even in the Pensky-Martens tester because the stirrer is located at the bottom of the cup with the thermometer just above, and convection is not vigorous in the upper layers in contact with the air. To determine the difference in temperature between the top and bottom of the paint, a sample of paint of about the viscosity of the camouflage paints was prepared with Varsol as a thinner and introduced into the cup. The thermometer was inserted in its usual position just above the stirrer, and another thermometer was inserted through the air vent with the bulb slightly below the surface of the paint. The stirrer was set in motion and heat was applied such that the temperature rose at the rate of 2 F. per min. Both thermometers recorded the same temperature at each 2 F. interval. This proved that the paint was satisfactorily stirred at this rate of heating.

A sample of the same paint was then introduced into the Tag closed cup tester. A thermometer was placed in the water bath in the usual manner; another thermometer was placed in the paint as near as possible to the wall of the cup, and another in the normal position in the center of the sample. The data given in Table III were obtained by heating in the usual manner.

TABLE III.—VARIATIONS OF TEMPERATURE IN THE TAG CLOSED CUP TESTER.

Temperature of Water Bath, deg. Fahr.	Temperature of Paint Nearest the Cup, deg. Fahr.	Temperature of Paint at Center, deg. Fahr.
90	84	80
96	87	81
100	91	81
103	94	82
106	98	85
108	101	87
110	102	88
110	105	92
111	106	94
115	108	95
120	111	97
122	114	99
126	117	101
130	120	103
132	123	105
137	126	107
138	128	108

It is to be noted that when the temperature in the center of the cup was equal to the flash point of any one of several paints previously determined by the Tag closed cup tester, the temperature in the outer portion was close to the flash point determined by the Pensky-Martens tester. The comparisons, taken from Tables I and II and from a plot of the data given in Table III, are shown in Table IV.

It is evident that flashing occurred in the Pensky-Martens tester at or a little below the temperature of the hottest part of the paint when flashing occurred in the Tag closed cup tester. Some irregularity is to be expected because of the different viscosities of the paints, and the somewhat lower average of the Pensky-Martens tester result is also to be expected since only a small portion of the exposed area in the Tag closed cup tester was at the temperature of the rim.

TABLE IV.—COMPARISON OF AVERAGE TEMPERATURES OF THE PENSKY-MARTENS AND THE TAG CLOSED CUP TESTERS.

Observed Flash Points of Paints from Tables I and II, deg. Fahr.		Temperatures in Tag Closed Cup Tester from a Plot of Table III, deg. Fahr.	
Tag Closed Cup Tester	Pensky-Martens Tester, Average	Center	Outside
82	94	82	94
83	90	83	96
90	105	90	104
94	105.5	94	106
96	106	96	109.5
96	108	96	109.5
98.5	111	98.5	115

Of course, the flash point of a paint is higher than that of its volatile solvent because of the lowering of the vapor pressure of the solvent when the heavier paint vehicle goes into solution.

Conclusion

1. Both instruments give reproducible results with even a viscous paint.
2. The two instruments give practically the same value for the flash point of a mobile liquid.
3. Values for the flash points of viscous materials obtained by means of the Tag closed cup tester are lower by 12 to 15 F. than those obtained by means of the Pensky-Martens tester.
4. There are large differences of temperature between different portions of a very viscous material in the Tag closed cup tester. The thermometer in its normal place in the center indicates a temperature lower than that at the periphery. When flashing occurs, the temperature of the latter is near to but tends to be higher than the flash point observed for the stirred paint in the Pensky-Martens tester.
5. If the Pensky-Martens tester is adopted for viscous paints, it may be expected to give flash points at least 10 F. higher than the Tag closed cup tester, and this should be taken into account in the specification.

Research on Powder Metals Inflammability

Based on extensive work carried on at its laboratory at Bruceton, Pa., the U. S. Bureau of Mines has issued pertinent data on the inflammability of powdered metals used in connection with war and related work. From its efforts in connection with coal mine dust the Bureau has had a background of very valuable research data, and this has been translated through many additional investigations to cover such metallic dusts as aluminum, antimony, cadmium, chromium, copper, iron, lead, magnesium, tin, zinc, and zirconium. Zirconium, a costly metal which is used in ammunition primers, has been described as "particularly dangerous." A cloud of zirconium powder ignited spontaneously at room temperature and exploded, whereas other metallic dusts in the "highest explosibility" class required temperatures hundreds of degrees higher before they ignited. As a result, powdered zirconium should be handled only as a sludge or in special containers. Some of the Bureau's work in the testing of metallic dusts is described in Bureau of Mines Information Circular 7241, "Annual Report of Research and Technologic Work on Coal, Fiscal Year 1942," by Dr. A. C. Fieldner (Past President of A.S.T.M. and Chairman, Committee D-5 on Coal and Coke) and W. E. Rice, Senior Fuel Engineer.

Discussion of Paper on Behavior of Glazing Material Subjected to Explosion[1]

Submitted by T. R. Eilenberg[2] and W. K. Jones:[2]

The writers have read with great interest the report of the comprehensive tests conducted by Mr. Adams, on the problems of glass breakage from bursting bombs.

The method used in these tests, of duplicating as closely as possible the actual explosive effect of the bomb is certainly a great improvement over the dubious and unrealistic methods of test by dropped weights or swinging hammers which have been reported in the technical journals in the recent past.

Mr. Adams points out the uncertainty of predicting the action of blast waves, which are often deflected and reflected in a very erratic way by even the most trivial obstruction in the path. Even under the best conditions of control it is difficult to say whether each test blast produces, at a particular point, repetitions of a force consistent with distance from explosion and size of charge used.

With the realization that reproduction of blasts duplicating true bombing conditions would be difficult, yet feeling that some kind of full-scale test should be made to investigate the glass hazard, the Commercial Buildings and the Mechanical Engineering Departments of the Consolidated Edison Co. of New York, Inc., undertook a series of tests, based upon a somewhat different procedure and approaching the problem from the point of view of a building operator whose task it was to uncover a practical expedient to cope with a present emergency.

A quick survey of the company buildings disclosed that they contained several million square feet of glass area, much of it 1/4 in. thick plate glass, plain and wired. All of the buildings are in city areas so that all are exposed to the same probability of bombing. A certain number of windows in each building could be singled out as offering more hazard to personnel and equipment than others, although this selection might undergo modification depending upon conditions. The assumption was made that a close hit might occur adjacent to any of these windows, which would break the glass and scatter it with great force across the room. The assumption was also made that the glass would be projected inward toward the office personnel whose safety was our immediate concern. It was further assumed that the human factor involved in closing shutters or drop panels over windows could not be depended upon to function at the time of an emergency. The problem was thus narrowed down to providing a means of protection which would offer minimum interference with the normal use of the window, yet would be in place at all times for the protection of the employees.

A steel plate test chamber was made up as indicated in the accompanying Fig. 1 to provide a means of repeating similar explosions adjacent to removable test panes.

These explosions were arranged to produce a wave front simulating that of a close bomb hit which would break the glass and scatter the fragments for a distance at least the depth of a business office or about 30 ft. The explosive force was provided by a mixture of illuminating gas and air ignited within the chamber by means of automobile spark plugs.

Movie films were made of the tests using the usual 16 frames to the second camera. One film was made through the courtesy of the Eastman Kodak Co. recorded at the rate of 1000 frames per second camera. This film discloses some very interesting details of the progress of the explosion and the whirling motion of the glass splinters. (Fig. 2.)

Our tests were made upon 1/4 in. thick plate glass panes secured in metal frames similar to the sash units supplied with the usual office building type of double-hung metal window. Preliminary tests using liquid coatings and tape bindings confirmed the findings of Mr. Adams, that such materials provide little or no protection from shattering under severe blast. Their effect was merely to increase the size of the fragments scattered. Wire glass was found to be subject to the same disadvantage. Roofing felt and similar materials pasted to the glass afforded little protection against heavy blast. Cheese cloth or other woven fabrics pasted to the glass and overlapping the sash provided some protection, in the sense that it held the fragments of glass together and reduced the distance to which the fragments in a mass were thrown.

All materials and adhesives applied to the glass are subject to more or less deterioration from exposure to the sun and other weather influences.

A number of tests were made to determine the effectiveness of a solid barrier behind the window, such as that of a 1/4-in. thick plywood sheet secured to a wood frame of 2 by 3-in. strip. When such a barrier was secured close up to the sash, it was badly broken by the blast and glass fragments were blown through the openings. However, if the plywood panel was moved back from the glass and secured in front of the opening with extension brackets so that a 6-in. wide marginal space existed between the face of the chamber and the barrier, the force of the blast appeared to be dissipated through this opening and most of the glass dropped harmlessly at the base of the barrier. The resilient nature of the plywood sheet appeared to absorb a portion of the energy of the wave and turned its direction so that its remaining force was dissipated sidewise. The usefulness of such a barrier is evident in a factory interior where blackout as well as glass protection is desired. Plywood panels could be hinged from ceiling fastenings and lowered into place at night or during a daylight raid, ventilation being provided through the marginal space.

[1] F. W. Adams, "Behavior of Glazing Material Subjected to Explosion," ASTM BULLETIN, No. 122, May, 1943, p. 15.

[2] Assistant Structural Engineer, Mechanical Engineering Department, and Engineering Inspector, Commercial Buildings Department, respectively, Consolidated Edison Co., of New York, Inc., New York, N. Y.

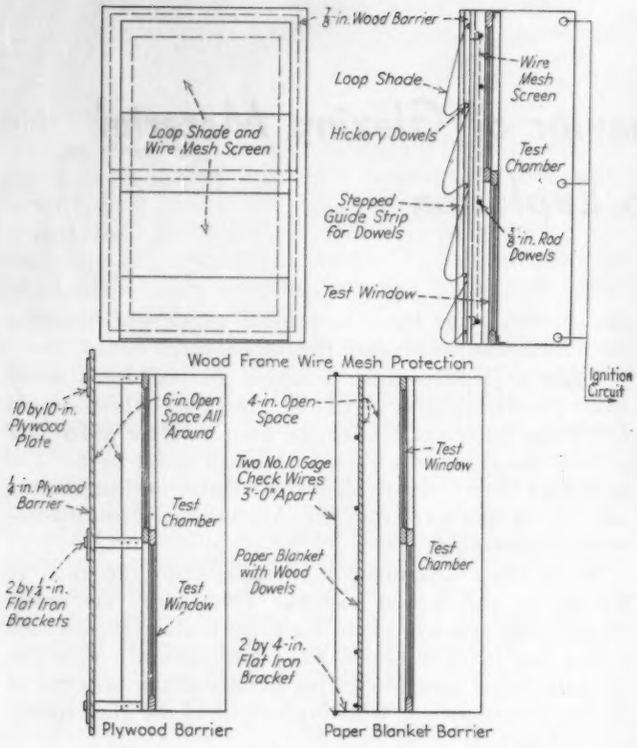


Fig. 1.—Window-Protection Test Chamber.

Fig. 2.—Test Chamber with Wire Mesh Guard and Blackout Curtain During Blast.

A test was made on another material much under discussion at the time. This consisted of a layer of heavy felt-like material such as used under carpets for padding. This blanket was secured with tie wires and washers to a section of steel factory sash glazed with $^1/_4$-in. wire glass. The effect of this blanket application was to so seal in the force of the blast that glass, window frame, and blanket were thoroughly wrecked. This confirmed the importance of obtaining venting effect.

Drawn venetian blinds were considered by some people to provide valuable protection. A test blast made behind such a drawn blind shattered tapes, slats and head board. The blind offered little impediment to the flying glass.

A thin plastic material secured in a light wood frame was tested as a possible temporary glazing material. The material is essentially a wire fly screen with the openings of the mesh sealed by a dipping of translucent plastic material. The effect of the explosion was to tear the material away from its fastenings along two edges, but the sheet was not blown clear of the frame. Venting an explosion by means of a light flexible material of this kind, durable enough to withstand the elements, and admitting some light seems to have a definite place in protection procedure. Material of this type should prove of great usefulness as a temporary protection following any extensive loss of present glass.

Tests were next conducted to determine an adequate protection for windows where it was important to retain full vision and ventilation and provide means for blackout. Two types of wire screen protection were developed for this purpose: (*a*) $^1/_2$-in. mesh hardware cloth, and (*b*) $^3/_8$-in. diamond mesh chain-link wire. Each type was set in a wood frame about 6-in. back of the glass, and both proved effective in retaining all flying glass except fine, grain-like particles which were projected only a few feet beyond the screen. The hardware cloth material, with openings of approximately $^1/_2$ in. square using a No. 16 gage wire, gave protection similar to that of the chain-link wire of $^3/_8$ in. diamond mesh, No. 16 gage wire. However, the chain-link wire, probably because of its greater resiliency, permitted fewer fine particles to pass through, and they were of smaller average size than those passed by the hardware cloth. Hardware cloth costs less than the link mesh but in the over-all cost of a window installation, the chain-link material permits simplification of construction so that both types of screens were about equal in cost. The chain-link screen, however, possesses the distinct advantage of flexibility so that it may be folded up to give access for window cleaning and the like.

The chain-link screen, because of its superior performance under test and its convenient provision for access to the sash, was adopted for trial installation and was installed at a number of windows in offices which must remain active during emergency periods.

A drop shade with folding loops was installed behind the screen to provide blackout of the window, and to catch the fine grains of glass which might cause eye injury (Fig. 3).

After the adoption of the wire mesh method, difficulty in obtaining delivery of the material made it advisable to investigate alternate methods. Two very interesting paper materials were proposed for test. Both of these were made up of many layers of paper quilted and stitched

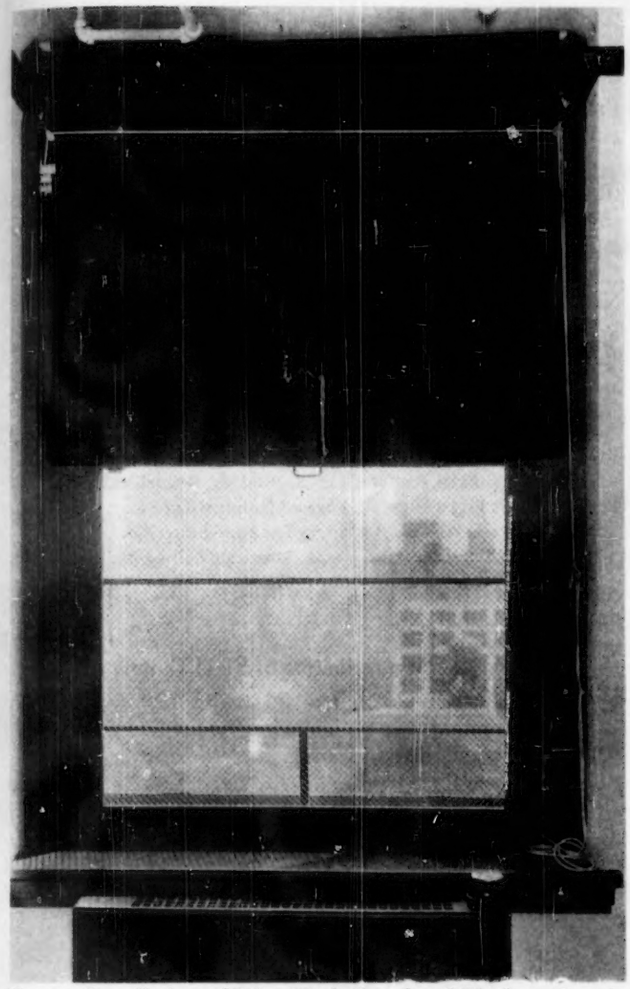


Fig. 3.—Installation of Wire Mesh Guard and Blackout Curtain at Office Window.

to form a blanket. The first made use of heavy kraft paper, die punched and expanded to permit passage of air. The second made use of pleated tissue, freely expandable. Both were quite effective in relieving the blast and restraining the particles of shattered glass. These paper materials are fireproofed and lend themselves to the type of installation where the blanket could be rolled or gathered in a loop at the head of the window, to be released by a pull cord upon an air raid signal. Except for the necessity of someone remembering to lower the protective blanket it appears that these inexpensive and readily obtainable paper materials have definite possibilities for many protection applications. It is to be expected that materials of this type will require more maintenance than wire mesh screens.

One test was made with a tempered type of plate glass which confirmed the fact that this glass under heavy blast shatters into crystalline grains of small size. No extensive testing of the safety or laminated glasses was undertaken, however, as it was felt excessively expensive and impractical to attempt the reglazing of sash at this time.

The hazard of flying glass can be best met by providing a strong, adequately fastened, resilient barrier in the window opening, so designed as to allow for the absorption and venting of the blast wave and at the same time arresting the shower of glass fragments.

Closure by F. W. Adams:[3]

The author finds the results of Messrs. Eilenberg and Jones of great interest in extending our knowledge of the effect of explosive blasts on glass scattering. Their interpretation appears to be logical and conclusive.

A word of caution about the use of this test method deserves to be added. The method of producing an explosion in a chamber lends itself admirably to a study of means of stopping scattered glass, provided the barrier is placed at a sufficient distance from the glass to permit venting of the gases from the chamber. There is considerable question as to whether it can be used to determine the resistance to explosive blast of various glazing materials.

An explosion of illuminating gas and air at atmospheric pressure is a slow combustion, without detonation. Depending on the gas concentration, a pressure up to a maximum of about seven times the initial pressure will be built up in about one hundredth of a second. Because there is no other outlet for the gaseous products of the explosion, they must rupture any glazing material which cannot withstand the pressure in the chamber (up to about 90 psi.). The greater the pressure at which the glazing material fails, the greater will be the energy available for projecting fragments.

Contrast this type of explosion with that of a high explosive. With a high explosive, a detonation wave travels at high velocity and reaches its peak pressure in a fraction of a thousandth of a second. The pressure developed at any point depends on the material of the high explosive, its weight, and its distance from the point, as well as many complicating reflection factors in the general terrain. The action of the pressure wave from this explosion and the suction wave following it is further affected by the frequency of the structure exposed to the blast.

Thus the effect on the breakage of a window of a high explosive bomb falling outside a building may be very different from that of a gaseous explosion in a chamber closed by the same window. The *scattering* of the glass will, in general, be in both directions in the former case and in only one direction in the latter case. The *ability of a barrier to stop the flying glass*, provided the barrier permits venting of the products of the gaseous explosion, will be similar in the two cases.

From this discussion, it may be concluded that the test method of Messrs. Eilenberg and Jones was suited to their purpose, namely, the selection of barriers for stopping flying glass fragments. Furthermore, their conclusions are in substantial agreement with the author's. The chamber test method is not adapted to and should not be used for measuring the resistance of glazing materials to explosive blast.

[3] Chemical Engineer, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

New Steel Limitation Orders

THREE NEW schedules were embodied in WPB Steel Limitation Order L-211 as of August 30, covering tubular products as follows: Schedule 11—Steel Pressure Pipe; Schedule 12—Steel Pressure Tubes; Schedule 13—Steel Pipe. On April 30, two other schedules relating to the piping materials field became effective, No. 9 covering Oil Country Tubular Goods, and No. 10, Water Well Tubular Products. These schedules establish limited numbers of quality specifications and permissible sizes that can be produced. A few notes about the schedules and material covered follow:

Schedule 9—Oil Country Tubular Goods—which means oil well casing, tubing, and drill pipe—may be used for any purpose, and other types of tubular material may be used in oil and gas wells, in each case subject to any restrictions contained in other orders of the War Production Board or the Petroleum Administration for War.

Schedule 10—Water Well Tubular Products—means water well drive pipe, water well casing, water well reamed and drifted pipe, driven well pipe and pump pipe, and couplings for same, manufactured from steel or wrought iron.

Schedule 11—Steel Pressure Pipe—provides specifications and standard sizes for steel pressure pipe commonly used in power plants and certain industrial plants. The specifications cover both carbon and alloy steel piping in lap-welded, seamless, electric-resistance-welded, and fusion-welded grades. A large portion of current production is already in substantial agreement with the provisions of the schedule. This does not cover any alloy steel with more than 10 per cent chromium, or recoil tubing.

Schedule 12—Steel Pressure Tubes—covers steel pressure tubes, includes boiler, cracking still, heat exchanger, condenser, and superheater tubes. They are especially important for oil, synthetic rubber, and chemical production. Does not cover alloy steel with more than 10 per cent chromium.

Schedule 13—Steel Pipe—sets up specifications for steel pipe, which is defined as follows: "Steel Pipe" means carbon and alloy steel, open-hearth iron and wrought iron pipe including main and line pipe in diameters up to 48 in. incl., standard pipe, signal pipe, piling pipe and fusion-welded casing. Excluded from the scope of this definition are forge-welded pipe, mechanical tubing, structural tubing, recoil tubing, conduit tubing, conduit pipe, corrugated pipe, dredge pipe, alloy-steel pipe and tubing having a chromium content in excess of 10 per cent, also oil country tubular goods, water well tubular products, steel pressure pipe and steel pressure tubing as defined in Limitation Order L-211, Schedules 9, 10, 11, and 12, respectively. This schedule will require a reduction of about 65 per cent in the number of sizes and wall thicknesses shown in various pipe mill catalogs.

Complete copies of the limitation orders can be obtained from the War Production Board, Washington, D. C., addressing the following:

WPB Inquiry Section,
Room 1501 Social Security Bldg.

In addition to these schedules, each of which includes specification requirements and which refer to various A.S.T.M. standards, Schedule 14 has been issued, relating to fence posts and Schedule 15 is the most recent one, dated September 15, setting up permissible nominal sizes in tolerances for hot-rolled carbon-steel bars including rounds, squares, ovals, flats, and bar size shapes (angles, channels, and tees under 3 in. on both legs).

National Emergency Steel Work:

With the exception of a few schedules relating to matters strictly of size the schedules which have been part of the L-211 order have been developed in the National Emergency Steel Project in which the A.S.T.M., S.A.E., and A.I.S.I. have cooperated. Many members of A.S.T.M. Committee A-1 on Steel have participated in the work and the official A.S.T.M. representative, N. L. Mochel, is chairman of Committee A-1, with Jerome Strauss, chairman of Committee A-10, as alternate. C. L. Warwick, Consultant, WPB Conservation Division, is Director of the National Emergency Steel project.

Schedules 9 through 13 were developed in a Technical Advisory Committee on Tubular Products headed by T. G. Stitt, Pittsburgh Steel Co. Chairmen of the respective subcommittees were as follows:

Oil Country Tubular Goods—H. W. Ladd, Stanolind Oil & Gas Co.
Water Well Tubular Products—L. H. Winkler, Bethlehem Steel Co.
Steel Pressure Pipe—H. R. Redington, National Tube Co.
Steel Pressure Tubes—H. B. Oatley, The Superheater Co.
Water Main Pipe—Russell Barnard, American Rolling Mill Co.

The administrators of these WPB schedules and addresses follow:

W.P.B. Administrators of Steel Orders

No. of Schedule	Products Covered	Date of Issue	Administrator	Room No. Social Security Bldg.	Extn. Tele.: Rep. 7500
1	Concrete Reinforcement Steel	Oct. 23, 1942	A. A. Wagner	1017	3875
2	Steel Wheels and Tires	Oct. 23, 1942	George Hocker	1308	2391
3*	Barbed Wire, Wire Fence, Poultry Netting and Poultry Flooring	Nov. 12, 1942	Norman Froelich	1520 A	73940
4	Structural Steel Shapes	Feb. 25, 1943 Amended, Sept. 2, 1943	M. W. Cole	1304	72404
5	Steel Axles and Forgings (Railroad and Transit Services)	Feb. 25, 1943 Amended, Aug. 19, 1943	George Hocker	1308	2391
6	Mechanical Steel Tubing	Feb. 25, 1943	W. H. Wiewel	1413	73486
7	Rails and Track Accessories	Feb. 25, 1943 Amended, May 6, 1943	George Bruner	1009	4860
8	Carbon Steel Plates	Mar. 22, 1943	M. W. Cole	1304	72404
9	Oil Country Tubular Goods	Apr. 30, 1943	J. W. Owings	1419 A	73034
10	Water Well Tubular Products	Apr. 30, 1943	J. W. Owings	1419 A	73034
11	Steel Pressure Pipe	Aug. 30, 1943	J. W. Owings	1419 A	73034
12	Steel Pressure Tubes	Aug. 30, 1943	W. H. Wiewel	1413	73486
13	Steel Pipe	Aug. 30, 1943	J. W. Owings	1419 A	73034
14*	Steel Fence Posts	July 6, 1943	Norman Froelich	1520 A	73940
15	Hot Rolled Carbon Steel Bars	Sept. 15, 1943	W. F. Vosmer	1017	3473

* These schedules are not under the cognizance of NESS.

All of these administrators are located in the Iron and Steel Division, and the room numbers and telephone numbers are as of September, 1943.

Emergency Standards for Standard Grade Lumber

NATIONAL EMERGENCY Specifications for the Design, Fabrication, and Erection of Stress Grade Lumber and its Fastenings for Buildings have been established with WPB Directive No. 29. These requirements which are intended to conserve lumber and timber will be mandatory on construction involving contracts placed after November 1, but Federal Agencies may put the specifications into effect immediately. Outstanding contracts for construction requiring stress grades of lumber must be reviewed and the new specifications written in where substantial delay to the war effort will not result.

With the working stress increased by 20 per cent, it is estimated there will result a saving of about 150,000 board feet per year, which is a substantial proportion of stress grade lumber production. An estimated saving of 2500 tons of steel in fixtures used with such lumber also should result from the specifications.

Comparison of Methods for Determining the Drying Rates of Varnishes[1]

By Howard R. Moore[2]

Although A.S.T.M. Standard Methods of Testing Varnishes Used for Electrical Insulation (D 115 – 41),[3] and Standard Methods of Testing Drying Oils (D 555 – 41)[4] include provisions for measuring certain stages of the drying time cycle, it is not generally recognized that A.S.T.M. Standard Methods of Testing Oleoresinous Varnishes (D 154 – 38)[5] fails to include methods for measuring drying time. Thus it has been tacitly assumed by many technicians that the methods adopted in Federal Specifications, of which Specification TT-V-121a for Varnish; Spar, Water-Resisting, is a typical example, have been incorporated in the A.S.T.M. Methods D 154, but this is not the case. There may be some justification for this assumption in view of the fact that the A.S.T.M. pioneered the development of the definitions and methods of test incorporated in the Federal Specifications. For example, the methods given for set-to-touch and dry-hard in current Federal Specifications[6] are identical with the phraseology used in the 1922 and 1924 Committee D-1 reports on Paint, Varnish, Lacquer, and Related Products.[7] It should be clearly understood, however, that these methods have never been incorporated in Methods D 154.

The desirability of improving drying time methods has been recognized by Subcommittee IX on Varnish for a number of years. However, very little has been done in considering changes in test methods subsequent to the report of Sanderson,[8] or in advancing the 1922 to 1924 finger-touch methods to the status of an approved A.S.T.M. method. This circumstance is not altogether unfortunate, since the results of this investigation appear to justify some delay in recommending adoption of either Government or industrial methods in current use. These tests indicate that the drying time problem is exceedingly complex and that further work must be done in order to establish definitions and test methods that will lead to concurrent results by different operators.

Scope of Collaborative Tests:

The finger-touch tests were undertaken with the primary object of determining the extent of interlaboratory agreement of drying time observations carried out according to the present Federal specification criteria. The instrumental tests were then undertaken to determine the degree of correlation with the finger-touch results.

In conducting the finger-touch tests, six representative varnish and alkyd resin liquids, Table I, were sent to the eleven collaborators listed in Table II. These particular compositions were chosen because of their anticipated differences in drying rates and final hardnesses. In conducting the instrumental tests, the same varnish liquids were submitted to the eight observers listed in Table VI, two of whom also obtained finger-touch data.

TABLE I.—VARNISH LIQUIDS SUBMITTED FOR TEST.

Varnish	Material	Viscosity (Gardner-Holdt Bubble Stds.)	Percentage Solids	Metal Naphthenate Driers Content; Referred to Percentage of Oils (Varnishes), Referred to Percentage of Solids (Alkyds)		
				Lead	Cobalt	Manganese
A	Phenolic resin varnish, 25 gal. length, based on a 50/50 tung oil linseed oil ratio (Bureau of Ships Specification 52V17)	G	54.4	0.6	0.04	0.02
B	Phenol modified alkyd resin	E–F	40.1	0.4	0.04	..
C	Alkyd resin, long soya modified type (Bureau of Ships Specification 52R13)	H	51.0	0.6	0.03	..
D	Rosin modified phenol resin varnish 35 gal. length, based on an 85/15 dehydrated castor oil tung oil ratio. (This varnish was not gas proofed.)	G–H	51.3	0.5	0.05	..
E	Pure phenolic resin varnish 40 gal. length, based on alkali refined linseed oil	F	60.5	0.3	0.01	0.02
F	Ester gum varnish, 40 gal. length, based on dehydrated castor oil	E	49.7	0.5	0.05	..

Finger-Touch Tests

Collaborators were requested to determine the three stages of drying in their regular laboratories and in air-conditioned rooms, if available. The first two intermediate stages were taken from the May 7, 1935, issue of Federal Specification TT-V-121a: namely,

1. *Set to touch:* The varnish is considered to have set to touch when gentle pressure of the finger shows a tacky condition but none of the varnish adheres to the finger.
2. *Dry Hard and Firm:* The varnish is considered to have dried hard when the pressure that can be exerted between the thumb and finger does not move the film or leave a mark which remains noticeable after the spot is lightly polished. If rapid light rubbing breaks the surface, the sample is considered not to have dried hard.

The third and final stage was identical with the definition given in Amendment 3 of the same specification dated October 8, 1941, except that the additional phrase "light touching" was inserted by the writer in order to encourage collaborators to investigate the effects of variable pressures on the results.

3. *Dry Hard - Tack Free:* After arriving at the dry hard stage, the varnish shall show no tack or pull on the thumb *by light touching* or under the pressure that can be exerted on it between thumb and forefinger.

[1] **NOTE.**—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] Presented before the Society's Committee D-1 on Paint, Varnish, Lacquer, and Related Products, at the Forty-sixth Annual Meeting, of the American Society for Testing Materials, Pittsburgh, Pa., June 30, 1943.

[2] Paint Technologist, U. S. Navy Yard, Philadelphia, Pa.

[3] 1942 Book of A.S.T.M. Standards, Part III, p. 298.

[4] 1942 Book of A.S.T.M. Standards, Part II, p. 844.

[5] *Ibid.*, p. 890.

[6] See, for example, Federal Specification TT-P-141 dated August 7, 1941, Paint, Varnish, Lacquer and Related Materials; General Specifications (Methods for Sampling and Testing).

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 376 (1922); also Vol. 24, Part I, p. 452 (1924).

[8] J. McE. Sanderson, "Report of Group 1, of Subcommittee IX on Varnish, of Committee D-1," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 324 (1926).

TABLE II.—TEST METHODS USED BY COLLABORATORS ON THE FINGER-TOUCH METHOD.

Collaborator	Company	Conditions of Test						
		Reg. Lab.	Controlled Relative Humidity and Temperature	Type of Panels	Wet Film Thickness, in.	Illumination	Draft (Air Movement)	Remarks
No. 1—J. R. Patterson	General Electric Co.	X	X	Steel, 4 by 12 in. (flow-out)	...	Fluorescent lighting	Air recirculated every 3 min. with addition of 15 to 20 per cent fresh air	2 series of tests middle of panel at relative humidity of 50 per cent (77 F.) and 65 per cent (77 F.) Readings at 65 per cent relative humidity usually greater
No. 2—M. E. Stearns	R. T. Vanderbilt Co.	X	X	Tin (flow-outs)	...	.....	.....	Tack-free points recorded in days because they were very indefinite
No. 3—V. M. MacNulty[a]	Hercules Powder Co.	X ..	X X	Tin (flow-outs) Glass (Hercules method)	... 0.005	Fluorescent lighting in air-conditioned room	.....	Tests in middle of panel; fingers dusted with talc; average of 2 operators; additional tests made according to Hercules definition of set, dust-free, tack-free and bone dry. Dry hard omitted
No. 4—F. Scofield	National Paint, Varnish and Lacquer Assn.	X	X	Not specified	...	.....	.....	None
No. 5—S. H. Richardson	Bakelite Corp.	X	X	Glass and cold rolled autobody steel (flow-outs)	...	.....	Moderate circulation	Results given for steel only; hands cleaned 1/2 hr. before making measurements
No. 6—E. F. Hickson	National Bureau of Standards	X	X	Glass, window and black carrara (flow-outs)	...	North windows daylight plus artificial light of 11-ft. candles for 8 1/2 hr. daily	Blower operated for 10 min. 3 times daily (2 1/2 cu. ft. per sec.)	Panels placed in nearly vertical position for 10 min. Set and dry hard according to TT-V-121a; tack according F-TT-V-121a; observations in triplicate
No. 7—C. J. Kaiser	Reichhold Chemicals, Inc.	..	X	Glass	0.002	.....	.....	None
No. 8—R. A. Allen	Nuodex Products Co., Inc.	X	..	Not specified	...	.....	.....	Dry hard and tack-free points stated to be practically the same for all varnishes
No. 9—A. Skett	American Gum Importers, Inc.	X	..	Glass	0.003	.....	.....	Contiguous drawdowns on glass plate
No. 10—W. W. Cranmer	Navy Yard, Phila., Pa.	X	..	Tin (flow-outs)	...	.....	.....	None
No. 11—W. H. Lutz	Pratt & Lambert, Inc.	X	..	Not specified	...	.....	.....	Average results of 3 independent observers at different relative humidity and temperatures

[a] Present address: Carpenter-Morton Co., Boston, Mass.

This tentative definition of tack may be justified in view of the absence of a general consensus of opinion as to how tack should be measured. Thus, Sward favors light touching in accordance with the statement:[9]

"For after tack or 'plain tack,' I press the finger *lightly* on the film and try to note any tackiness or stickiness."

and Hickson,[9] heavy pressure as follows:

"application of pressure between the thumb and forefinger for two seconds as given by the February 10, 1943, issue of Federal Specification E-TT-V-121a."

The method of light touching seems preferable in view of the fact that certain rapid-drying synthetic resin films become tack free before they attain print proofness, and conversely other types attain print proofness before after-tack disappears. Low pressures are usually sufficient to distinguish the residual tackiness of certain types of cold cut resins and oils long after the film has arrived at a state of permanent print proofness.

In submitting test results for the third stage of drying, Table III, none of the eleven independent observers discriminated between the end points obtained by light touching and heavy pressure. Presumably they interpreted the dry hard and tack-free stage in accordance with their own routine methods and conditions of test described in Table II. The majority of the collaborators made laboratory flow-outs of the six varnishes to conform with Federal methods of test as requested, but Nos. 3, 7, and 9 made drawdowns of controlled wet film thickness on glass.

[9] Private communications, G. G. Sward, National Paint, Varnish and Lacquer Assn., Washington, D. C.; and E. F. Hickson, National Bureau of Standards, Washington, D. C.

TABLE III—SET-TO-TOUCH, DRY-HARD, AND DRY HARD-TACK FREE TIMES.

Observer	Temperature; Relative Humidity		Varnish A		Varnish B		Varnish C		Varnish D		Varnish E		Varnish F	
	Regular Laboratory (a)	Air-Conditioned Room (b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
SET-TO-TOUCH TIME, HR.														
No. 1	.....	77 F.; 50%	1.2	1.0	0.5	0.3	2.0	1.7	2.7	2.3	2.6	2.1	2.2	1.8
No. 2	69 F.; 58%	70 F.; 50%	0.3	0.8	0.3	0.5	1.3	1.5	2.5	2.0	2.8	2.0	2.0	1.8
No. 3	75 to 88 F.; 50 to 95%	75 F.; 50%	0.8	0.7	0.4	0.4	1.5	2.3	2.3	2.3	2.3	2.3	2.0	2.0
No. 4	86 F.; 72%	77 F.; 65%	0.6	0.7	0.6	0.6	1.2	1.5	1.9	2.9	1.7	2.4	1.5	1.7
No. 5	79 to 82 F.; 65 to 79%	77 F.; 50%	1.0	1.0	2.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
No. 6	77 to 93 F.; 40 to 75%	77 F.; 50%	0.5	0.6	0.3	0.4	1.0	1.0	1.8	2.3	1.5	1.8	0.8	0.8
No. 7	.....	77 F.; 50%	...	0.9	...	0.4	...	2.0	...	2.8	...	2.2	...	1.7
No. 8	74 F.; 65%	.....	0.7	...	0.4	...	2.0	...	2.1	...	2.0	...	0.9	...
No. 9	.....	.....	1.5	...	2.0	...	6.0[a]	...	6.0[a]	...	6.0[a]	...	6.0[a]	...
No. 10	77 to 80 F.; 40 to 60%	.....	0.8	...	0.5	...	1.3	...	2.5	...	2.5	...	2.3	...
No. 11	71 to 91 F.; 41 to 71%	.....	0.5	...	0.2	...	1.0	...	1.5	...	1.7	...	1.2	...
Avg. Values	.....	.....	0.7	0.8	0.7	0.7	1.6	1.7	2.2	2.5	2.2	2.3	1.8	1.8
DRY-HARD TIME, HR.														
No. 1	.....	77 F.; 50%	8.5	7.5	8.0	6.0	2.8	2.7	3.5	3.0	2.8	2.3	3.0	2.5
No. 2	69 F.; 58%	70 F.; 50%	2.8	2.5	4.3	4.8	5.3	5.5	10.0	11.5	10.5	12.0	11.3	12.0
No. 3	75 to 88 F.; 50 to 95%	75 F.; 50%	2.5	2.0	4.0	7.0	7.0	7.0	9.0	8.0	9.0	9.0	8.0	7.5
No. 4	86 F.; 72%	77 F.; 65%	1.8	1.8	2.2	3.0	2.4	3.0	4.0	5.2	4.0	4.6	2.4	2.9
No. 5	79 to 82 F.; 65 to 79%	77 F.; 50%	8.0	8.0	24.0[a]	24.0[a]	6.0	6.0	6.0	6.0	8.0	8.0	8.0	8.0
No. 6	77 to 93 F.; 40 to 75%	77 F.; 50%	2.8	1.8	4.0	4.0	4.0	4.0	5.3	5.6	5.1	5.4	7.2	7.2
No. 7	.....	77 F.; 50%	...	4.0	...	5.0	...	4.1	...	9.2	...	9.1	...	11.0
No. 8	74 F.; 65%	.....	2.2	...	3.3	...	5.9	...	9.8	...	10.2	...	8.0	...
No. 9	.....	.....	2.3	...	6.0	...	8.0	...	16.0[a]	...	18.0[a]	...	20.0[a]	...
No. 10	77 to 80 F.; 40 to 60%	.....	3.0	...	3.5	...	4.5	...	8.0	...	8.0	...	8.0	...
No. 11	71 to 91 F.; 41 to 71%	.....	3.2	...	5.6	...	4.2	...	6.3	...	6.2	...	8.1	...
Avg. Values	.....	.....	3.7	3.9	4.5	5.0	5.0	4.6	6.9	6.9	7.1	7.2	7.1	7.3
DRY-HARD - TACK-FREE TIME, HR.														
No. 1	.....	77 F.; 50%	8.5	7.5	8.0	7.0	24.0	24.0	30.0	30.0	30.0	30.0	30.0	30.0
No. 2	69 F.; 58%	70 F.; 50%	5.3	5.3	5.8	6.5	48.0	48.0	72.0	72.0	72.0	72.0	96.0	96.0
No. 3	75 to 88 F.; 50 to 95%	75 F.; 50%	7.0	4.5	15.0	15.0	96.0	84.0	96.0	84.0	96.0+ (bad tack)	96.0+	96.0	72.0
No. 4	86 F.; 72%	77 F.; 65%	1.8	1.8	3.5	3.5	4.0[a]	5.5[a]	8.0[a]	8.0[a]	16.0[a]	16.0[a]	24.0	24.0
No. 5	79 to 82 F.; 65 to 79%	77 F.; 50%	24.0[a]	24.0[a]	96.0[a]	96.0[a]	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0
No. 6	77 to 93 F.; 40 to 75%	77 F.; 50%	6.5	5.0	12.0	12.0	110.0	110.0	32.0	29.0	26.0	26.0	120.0+	120.0+
No. 7	.....	77 F.; 50%	...	7.0	...	7.5	...	96.0	...	96.0	...	96.0+	...	96.0
No. 8	74 F.; 65%	.....	2.2	...	3.3	...	5.9[a]	...	9.8[a]	...	10.2[a]	...	8.0[a]	...
No. 9	.....	.....	6.5	...	8.0	...	44.0	...	44.0	...	44.0	...	44.0	...
No. 10	77 to 80 F.; 40 to 60%	.....	24.0[a]	...	24.0[a]	...	30.0	...	30.0	...	30.0	...	30.0	...
No. 11	71 to 91 F.; 41 to 71%	.....	6.5	...	18.0	...	18.3	...	26.5	...	48.0	...	44.0	...
Avg. Values	.....	.....	5.5	5.2	9.2	8.6	58.3	76.3	53.3	67.8	55.3	69.3	64.4	76.3

[a] These results were discarded in computing averages.

TABLE IV.—EFFECT OF FILM THICKNESS ON THE THREE STAGES OF DRYING BY THE FINGER-TOUCH METHOD (J. J. BRADLEY, JR.).

Wet Film Thickness, in.	Drying Time, hr.																	
	Regular Laboratory Conditions, 90 F. and 50 per cent Relative Humidity						Air-Conditioned Rooms, 70 F. and 65 per cent Relative Humidity						Comparison Tests, Other Observers, Table II					
	Varnish No. E			Varnish No. F			Varnish No. E			Varnish No. F			Varnish No. E			Varnish No. F		
	Set	Dry Hard	Tack Free	Set	Dry Hard	Tack Free	Set	Dry Hard	Tack Free	Set	Dry Hard	Tack Free	Set	Dry Hard	Tack Free	Set	Dry Hard	Tack Free
0.001	1.1	1.5	10	0.7	1.3	>24	4.5	5.2	>24	0.8	3.5	8.3	..	...	...	..	...	...
0.0015	1.3	2.1	10	0.7	1.3	>24	4.5	5.2	>24	0.9	3.5	<24	...	...	...	...	...	...
0.002	...	...	...	...	...	...	...	...	...	...	...	....	2.2[b]	9.1[b]	96[b]	1.7[b]	11.0[b]	96[b]
0.0025	1.6	2.2	>24	1.1	2.6	>24	5.0	5.7	>24	1.5	3.9	>24	..	...	...	...	...	...
0.003	1.5	2.3	>24	1.2	6.0	>24	5.5	6.0	>24	1.6	8.5	....	6[c]	18[c]	44+[c]	6[c]	20[c]	44+[c]
0.005	2.3	4.1	>24	1.6	24	>24	6.1	<24	>24	4.5	>24	....	2.5[a]	...	96+[a]	1.8[a]	...	96[a]
0.007	2.4	>24	>24	1.7	24	>24	6.7	<24	>24	4.5	>24	....	..	...	...	..	...	...
0.010	2.4	>24	>24	2.0	24	>24	7.8	>24	>24	4.7	>24	....	..	...	...	..	...	...

[a] Observer No. 3, 75 F. and 50 per cent relative humidity.
[b] Observer No. 7, 77 F. and 50 per cent relative humidity.
[c] Observer No. 9, conditions not specified.

In computing the average drying times of each varnish, for each stage of drying, individual values that differed widely from those reported by the majority of the collaborators were disregarded. These abnormal values are designated.

Table III shows that 6 of the 10 observers who gave results for their regular laboratories conducted a duplicate series of measurements in air-conditioned rooms. One observer, No. 7, submitted results under controlled conditions only.

In order to secure data on the effect of film thickness on the end points obtained by Federal Specification criteria, J. J. Bradley, Jr., of Bird and Sons, was requested to submit data on the effect of film thickness, using a number of different applicators of graduated wet film thickness. The results obtained for varnishes E and F with eight drawdowns on plate glass of systematically increasing thickness are given in Table IV.

It is manifestly difficult to derive conclusions from data that show such wide variations. However, definite information was obtained on the following features of drying time tests that should be carefully considered in plans for further work: namely,

1. Relative accuracy of data obtained for each stage of drying under controlled conditions and in regular laboratories.

2. Relative importance of "environmental" and "intrinsic factors" in determining results.

3. Desirability of controlling film thickness of specimens measured.

The following discussion considers the foregoing topics in the order named.

Discussion of Finger-Touch Results:

Relative Accuracy of Data Obtained for Each Stage of Drying Under Controlled Conditions and in Regular Laboratories.—The general agreement between averages obtained in the regular laboratories and air-conditioned rooms, (the (*a*) and (*b*) columns of Table III) indicates that observance of special precautions of controlled temperatures and humidities does not materially reduce the range of values given by all observers. This conclusion is reinforced by the arithmetical ratios of Table V, obtained by computing the quotients of the longest to the shortest times of dry recorded for each varnish, excluding the values designated by the letter *a*. The order of agreement is very close for the dry hard stage.

TABLE V.—MAXIMUM PERCENTAGE VARIATIONS (11 OBSERVERS).

Varnish	Set to Touch		Dry Hard		Tack Free	
	Reg. Laboratory	Conditioned Room	Reg. Laboratory	Conditioned Room	Reg. Laboratory	Conditioned Room
A....	500	167	472	417	472	417
B....	1000	666	364	175	546	429
C....	300	230	334	259	603	459
D....	200	150	286	384	363	320
E....	200	167	368	522	369	369
F....	250	375	376	481	1000	1000
Avg...	408	292	367	373	559	499

The foregoing calculations indicate that the precaution of making determinations in air-conditioned rooms does not seem justified in view of the fact that each varnish shows approximately the same total percentage variation as obtained in regular laboratories. Although a close inspection of the readings of individual observers will show that temperature and relative humidity affect drying rate, it is certain that other factors inherent in the method are much more important in controlling the end points recorded by these methods of test.

The data given in Table V also show that the faster-drying varnishes A and B give approximately the same percentage variations as the slower-drying types, although the maximum differences in hours recorded for each stage of drying are much less. In general, these over-all percentages ratios show that the smaller time differences recorded for the set-to-touch and dry-hard criteria should not be cited in favor of a presumed higher accuracy of the first two definitions as compared to the tack-free definition.

Relative Importance of "Environmental" and "Intrinsic Factors" in Determining Results.—A detailed analysis of the results submitted in Table III as related to the special conditions of test used by the various observers, Table II, indicates that careful control of "environmental" factors (temperature, relative humidity, air circulation, purity of air, and lighting conditions) is of minor importance as compared to certain "intrinsic factors" dependent on the personal equation. These intrinsic factors are: intensity of finger pressure per unit area contacted, duration of pressure, and cleanliness of the fingers. Thus, Table II shows that there was poor correspondence in the data submitted by collaborators Nos. 1, 3, and 6, who had similar "ideal" environmental facilities in their laboratories (controlled air circulation, illumination, temperature and relative humidity). However, the results submitted by collaborators Nos. 3 and 5 show that observance of special precautions on cleanliness of the fingers might have been responsible for the good agreement obtained for varnishes C, D, E, and F. Collaborator No. 3 dusted the fingers with talc to avoid the effects of perspiration after cleaning the hands. Collaborator No. 5 eliminated oiliness by washing the hands thoroughly at least $^1/_2$ hr. before conducting measurements. When the hands became sticky with varnish, they were cleaned with xylol. Similarly, there was no correspondence in the results obtained by collaborators using the same types of surface for preparing flow-outs. Thus collaborators Nos. 2 and 3, using tin panels, did not get corresponding results nor did Nos. 1 and 5 using steel; nor Nos. 5 and 6 using glass. These results indicate that controlled "environmental" factors for conducting drying time measurements and the type of surface are secondary to individual interpretations of the end points corresponding to each of the three stages of drying. These "interpretations," in turn, are probably much more dependent on the state of cleanliness of the "contact elements," the fingers, and the degree of pressure exerted for definite contact times.

The great importance of the personal equation dependent on intrinsic factors has been further brought out by a comparison of results obtained by the *same* observer, in duplicate or triplicate, as compared to two or three *different* observers working in the same laboratory. In the first case, collaborators Nos. 3 and 6 reported excellent checks,

TABLE VI.—PHYSICAL CHARACTERISTICS OF VARIOUS DRYING-TIME INSTRUMENTS.

Instrument	Collaborator	Weight of Contact Element, g.	Duration of Contact (approx.)	Contact Area (approx.)
Parks Dry-O-Graph	M. E. Stearns (R. T. Vanderbilt Co.)	1030	7 min. per corrugation (est.)	50 sq. mm. per corrugation
Drying time recorder	W. Krumbhaar, Observer No. 1 (Krumbhaar Chemicals, Inc.) H. S. Klund, Observer No. 2 (H. A. Gardner Labs.)	732	10 min. per cog (est.)	70 sq. mm. per cog
Walker-Steele swinging beam	S. H. Richardson (Bakelite Corp.)	110	0.3–1.5-min. (est.) oscillation periods	2 sq. mm. (two-point contact)
Sward rocker arm	C. J. Kaiser, Observer No. 1 (Reichhold Chemicals) H. S. Klund, Observer No. 2 (H. A. Gardner Labs.)	98	Varies between 2–40 sec.; 0.016–0.04 sec. per mm. of path	11 sq. mm., average rocking distance of 44 mm.
Sanderson drying-time meter	J. L. Sherlock, Observer No. 1 (E. I. du Pont Co.) R. S. Mathews, Observer No. 2 (Archer-Daniels-Midland)	0.01–0.03	2–90 hr.	0.25 sq. mm. per grain
Rolling Ball Tester	M. N. States (Central Scientific Co.)	21.5	Averages 6 sec. per 100 cm.; 0.006 sec. per mm. of path	1 sq. mm. (one-point contact)

TABLE VII.—INSTRUMENTS UTILIZING HIGH-PRESSURE CONTACT ELEMENTS.

Varnish	Parks Dry-O-Graph (Contact Element Weighs 1030 g.)				Drying-Time Recorder (Contact Element Weighs 732 g.)			
	Lint Free, hr.		Print Free, hr.		Observer No. 1 (Tin Strips)		Observer No. 2 (Glass Strips)	
	69 F., 58 per cent Relative Humidity	70 F., 50 per cent Relative Humidity (Air Conditioned)	69 F., 58 per cent Relative Humidity	70 F., 50 per cent Relative Humidity (Air Conditioned)	75 to 85 F., 80 to 90 per cent Relative Humidity		77 F., 50 per cent Relative Humidity (Air Conditioned)	
					Set, hr.	Dry, hr.	Set, hr.	Dry, hr.
A	1.5	2.0	12.0	12.0	0.7	2.6	0.4	1.8
B	4.0	5.5	20.0	22.0	2.2	5.5	0.2	2.3
C	4.5	2.0	8.5	5.5	1.7	12.0	0.5	4.7
D	4.5	2.5	9.0	11.0	1.6	12.7	1.2	3.8
E	4.0	2.5	11.5	13.5	2.2	13.5	1.5	4.8
F	3.0	1.5	15.0	23.0	2.1	16.0	0.5	2.4

TABLE VIII.—INSTRUMENTS UTILIZING MEDIUM-PRESSURE CONTACT ELEMENTS.

Varnish	Walker-Steele Swinging Beam (Contact Elements Weigh 110 g.)				Sward Rocker Arm (Contact Element Weighs 98 g.)					
	Seconds After 29-hr. Drying on Steel		Seconds After 100-hr. Drying on Steel		Rocker Arm Values as Function of Drying Time, hr. (Samples Applied on Glass at 2 mils Wet-Film Thickness) 77 F., 50 per cent Relative Humidity (Air Conditioned)					
	79 to 82 F., 65 to 79 per cent Relative Humidity	77 F., 50 per cent Relative Humidity (Air Conditioned)	79 to 82 F., 65 to 79 per cent Relative Humidity	77 F., 50 per cent Relative Humidity (Air Conditioned)	3 (Obs. No. 1)	7 (Obs. No. 2)	18 (Obs. No. 1)	24	48	144 (Obs. No. 2)
A	74.0	76.0	150	130	7.5	4	11	11 (Obs. No. 1) 10 (Obs. No. 2)	12 (Obs. No. 1) 12 (Obs. No. 2)	13
B	21.0	40.0	116	106	3.0	1	11	11 (Obs. No. 1) 8 (Obs. No. 2)	14 (Obs. No. 1) 10 (Obs. No. 2)	10
C	14.5	14.5	18	21	0	0	1	2 (Obs. No. 1) 1 (Obs. No. 2)	3 (Obs. No. 1) 1 (Obs. No. 2)	1
D	21.0	24.0	25	25	0	0	1	1 (Obs. No. 1) 1 (Obs. No. 2)	2 (Obs. No. 1) 1 (Obs. No. 2)	1
E	24.8	24.8	25	25	0	0	1	1 (Obs. No. 1) 1 (Obs. No. 2)	2 (Obs. No. 1) 1 (Obs. No. 2)	1
F	17.8	21.4	49	49	0	0	3	4 (Obs. No. 1) 2 (Obs. No. 2)	8 (Obs. No. 1) 4 (Obs. No. 2)	5

but in the second, the degree of variation was so great that collaborator No. 11 was inclined to attribute the differences to the "baffling varnish types submitted, since each of his three observers had been conducting drying tests for at least 10 yr., and the inconsistencies reported cannot be attributed to lack of experience."

With respect to the relative importance of the various factors affecting the personal equation in drying-time measurements, it seems that degree of pressure per unit area contacted is the most important. The absence of quantitative controls for the degree of pressure, as specified by the terms "gentle pressure," "light touch," and "pressure between thumb and forefinger" would appear to account for the major lack of reproducible results by different observers. It seems clear that variations in degree of pressure per unit area contacted will produce more errors than can be corrected by observance of special precautions for cleaning the hands. However, it is understood that attempts are being made by Subcommittee 37 of the New York Paint and Varnish Production Club to standardize on the degree of pressure by use of a torsion balance. In this test the coated panel is placed on a torsion balance and a specified pressure is exerted by the finger.[10] This method does not take account of the necessity of a definite contact area for the finger, emphasized by Green[11] in his design of a mechanical Tackmeter. In applying his apparatus for determining the degree of tack of printing inks, Green states that the area of the film will alter judgment as the fourth power of the radius of the contact element is involved. Thus, if the area is doubled, the pull resistance is increased sixteen fold.

[10] L. Auer, private communication, Ridbo Laboratories, Inc., Paterson, N. J.

[11] Henry Green, "What Is Tack," *Paper Trade Journal*, Vol. 114, No. 6, pp. 39–42 (1942); also "The Tackmeter, an Instrument for Analyzing and Measuring Tack," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 13, p. 632 (1941).

TABLE IX.—INSTRUMENTS UTILIZING LOW-PRESSURE CONTACT ELEMENTS.

Varnish	Sanderson Drying Time Meter (Contact Elements, Individual Grains, Weigh 0.01 to 0.03 g.) Observer No. 1—Dry Film 0.8 mil, 77 F., 50 per cent Relative Humidity (Air Conditioned) Observer No. 2—Dry Film 1.5 mils, 79 F., 61 per cent Relative Humidity (Air Conditioned)				Rolling Ball Tester (Contact Element, Rolling Ball, Weighs 21.5 g.) Wet-Film Thickness 1.5 mils 72 to 90 F., 52 to 91 per cent Relative Humidity
	Brush Point, hr. (Set to Touch)		Tap Point, hr. (Tack Free)		Tack-Free Times, hr. (Rolling Times Constant to Within 0.1 sec.)
	Obs. No. 1	Obs. No. 2	Obs. No. 1	Obs. No. 2	
A	1.0	1.0	104	22	5.7
B	4.8	2.8	93	47	8.0
C	4.5	1.8	84	81	24.0
D	6.0	3.3	94	81	30.0
E	5.0	2.5	92	97	130.0
F	3.5	2.0	86	97	28.0

Desirability of Controlling Film Thickness of Specimens Measured.—The importance of controlling film thickness is graphically illustrated by Bradley's data, Table IV, obtained with a set of eight film applicators for varnishes E and F. These results indicate the desirability of a standard wet film thickness of 2 to 3 mils, in view of the fact that the average thickness of dry films is in the neighborhood of 1 mil. Dry film thicknesses obtained by the flow-out method will vary widely, depending on the viscosity and solids content of the varnishes and angle of inclination of the test panels.

Instrument Tests

The weights of the moving elements, as well as duration of contact and contact area with the varnish films, provide a convenient means of comparing the six instruments tested. In this connection, Table VI may be useful in visualizing the principles employed by these various instruments.

The results given in Tables VII, VIII, and IX are classified with respect to the weights of the moving elements

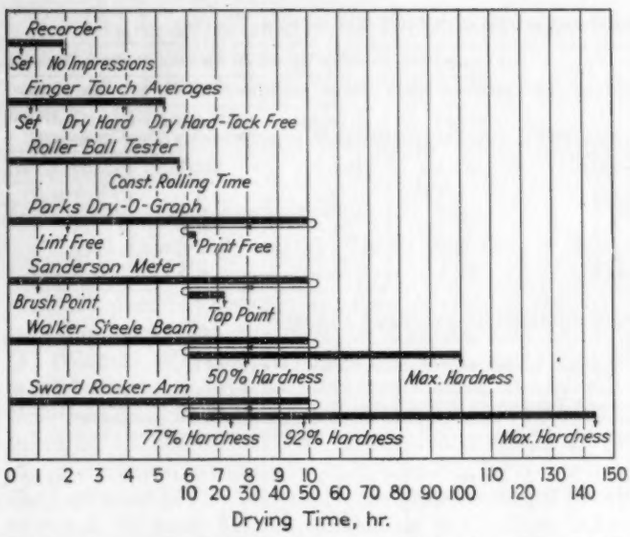


Fig. 1.—Instrumental and Finger-Touch Determinations at 77 F. and 50 per cent Relative Humidity for Varnish A.

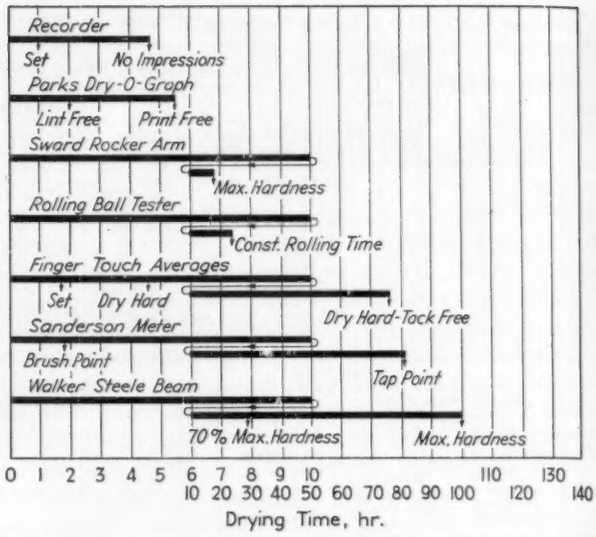


Fig. 2.—Instrumental and Finger-Touch Determinations at 77 F. and 50 per cent Relative Humidity for Varnish C.

in contact with the varnish films. All of these instruments, with the exception of the drying time recorder and rolling ball tester, are fully described by H. A. Gardner.[12] The design and principles of operation of the drying time recorder are given by P. N. Gardner.[13] The details of construction and operation of the rolling ball tester, improvised by the author and developed by M. N. States of the Central Scientific Co. as a laboratory instrument, are given in the section of this paper headed Further Details on the Rolling Ball Tester.

The results obtained are very complex, since they bear no evident relationships to the average of finger-touch observations. Nevertheless, it is advisable to state that the degree of correlation of these instrumental data with finger-touch observations should not be considered as the sole criterion for evaluating these devices. Abrupt stages of drying cannot really exist if the process of film solidification is continuous. However, for the purposes of discussion, the drying time averages given for air-conditioned rooms (the (*b*) columns of Table III), may be classified as ollows :

	Varnishes		
	Class I	Class II	Class III
Average set to touch.....	A, B (0.7 to 0.8 hr.)	C, D, E, F (1.7 to 2.5 hr.)	.....
Average dry hard.....	A (3.9 hr.)	B, C (4.6 to 5.0 hr.)	D, E, F (6.9 to 7.3 hr.)
Average dry hard and tack free.....	A (5.2 hr.)	B (8.6 hr.)	C, D, E, F (68 to 76 hr.)

In presenting the following discussion of instrumental results for heavy, medium, and light-pressure contact elements, the various physical and dimensional factors listed in Table VI have been duly considered, as well as the above averages of finger-touch observations made under controlled conditions of temperature and relative humidity.

Discussion of Instrumental Results:

Figures 1, 2, and 4 illustrate the differences brought out by a comparison of the finger-touch averages and instrumental data for three representative varnishes A, C, and F. Tentative explanations for these differences are given below for heavy, medium, and light contact elements, respectively.

Heavy Pressure Contact Elements:

Parks Dry-O-Graph.—A comparison of "lint-free" times with the average set to touch times (Table III) shows fair agreement for varnishes C, D, E, and F, but varnishes A and B gave results that are too high. The "print free" times, corresponding to disappearance of impressions of the corrugated brass roller, show no relationship to the dry hard data of Table III, either as to order of dry or numerical values.

Drying Time Recorder.—The first reading obtained with this device, corresponding to the time where the wheel no longer removes portions of the varnish films from the test strips, shows fair agreement with finger-touch observations of set to touch times for observer No. 1 only. The values obtained by observer No. 2 are roughly equal with respect to order of dry, but the numerical correlation is

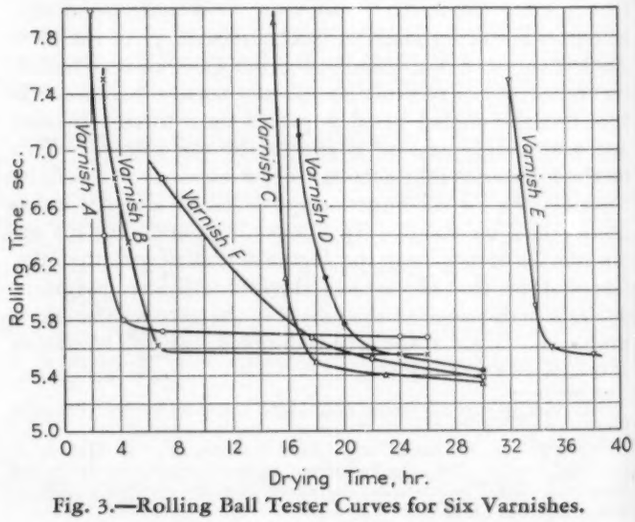


Fig. 3.—Rolling Ball Tester Curves for Six Varnishes.

[12] H. A. Gardner, "Paints, Varnishes, Lacquers, and Colors," Ninth Edition (1939).

[13] P. N. Gardner, "Drying Time Recorder," U. S. Patent No. 2,280,483, April, 1943.

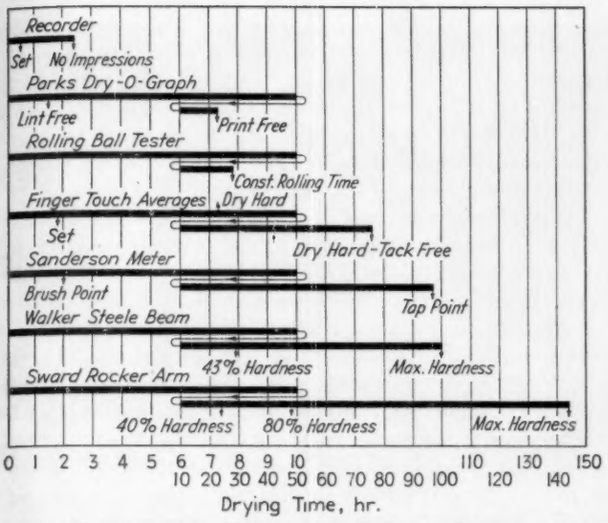


Fig. 4.—Instrumental and Finger-Touch Determinations at 77 F. and 50 per cent Relative Humidity for Varnish F.

poor. The second and final stage results, corresponding to the disappearance of impressions of the rectilinear cogs, are considerably lower than the finger-touch averages for dry hard and show poor agreement for order of dry.

Reference to Tables VI and VII indicate that these instruments measure a factor analogous to print resistance as a function of time because of the slow movement of their heavy contact elements. Consequently, it is logical to expect that the Parks Dry-O-Graph will show longer print-free times, on the average, than the drying time recorder, since the corrugated brass wheel weighs considerably more than the cogged wheel mounted in the floating housing provided by the recorder. The degree of plastic distortion effected by these elements is in direct proportion to weight and should be even greater for greater weights. This may explain why the final stage of drying given by the Parks Dry-O-Graph exceeds the finger-touch data for the second stage of drying, Table III.

In general, both of these instruments give preliminary readings intermediate between the set-to-touch and dry-hard averages of Table III. The final reading usually exceeds the dry-hard averages. Neither instrument measures the tack-free stage, since the final end points bear no relation to the presence or absence of surface tack. Incidentally, the longest time that can be measured with the drying time recorder is 16 hr. This is due to the fact that one revolution of the cogged wheel corresponds to a distance of 48.3 cm., the diameter of the wheel. The speed of the traveling table is adjusted to 30 mm. per hr. to provide contact of a fresh cog on the coating during the entire period of operation.

Medium Pressure Contact Elements:

Walker-Steele Beam.—Although the data for the Walker-Steele beam in Table VIII are very fragmentary, they show the right order with respect to dry hard for varnishes A and B. There is very little difference for varnishes C to F for a drying time of 29 hr. This method evidently measures changes in film characteristics considerably beyond the tack-free stage, since varnishes A and B show considerably higher readings after 100 hr. drying. It is clear that this instrument does not measure tack, since varnishes A and B acquire higher readings at 100 hr., considerably beyond the tack-free stage. Similarly, a comparison of the readings given for varnishes C, D, and E at 29 and 100 hr. shows that they are practically unaffected by the disappearance of substantial amounts of tack at the longer drying time. These results also indicate that the number of swings obtained may be related to film flexibility, as well as surface hardness. This may account for the low values reported for varnish C (alkyd resin) which has a Kauri reduction in the neighborhood of 200 per cent, considerably higher than the values of 75 to 100 per cent characteristic of the soft oil varnishes D, E, and F.

Sward Rocker Arm.—The results obtained by the two observers utilizing the Sward rocker arm are in substantial agreement. Varnishes A and B are in the proper order with respect to finger touch observations of 7 hr. and showed measurable increases over the range 18 to 144 hr. These results are consistent with the Walker-Steele beam data in that varnish F shows slightly greater hardness at 18 to 144 hr. than varnishes C, D, and E. Similarly, the data reported by observer No. 2 for varnishes C, D, and E over the range 18 to 144 hr. show that this device has no value for measuring tack. None of the varnishes showed increased rocker values when tack disappears. This device, like the Walker-Steele beam, evidently measures a composite factor proportional to intrinsic surface hardness and flexibility.

These pendulum methods are adaptations of the original Herbert pendulum developed to test the hardness of metals.[14] The results obtained by the Walker-Steele beam, Table VIII, are probably more useful from a drying time standpoint since they show a greater spread in numerical values. If an oscillation time of 18 sec. can be considered as representative of the dry hard stage, as suggested by Cochran and Graham,[15] it is clear that all of the liquids, except varnishes A and B, have arrived at this state 29 hr. after application. Neither device appears to differentiate surface tack from the final result, which is believed to represent the composite of surface hardness and resilience (flexibility).

Recent studies by Konig[16] indicate that Walker-Steele beam readings may have a more fundamental significance than was formerly supposed, if his claims are substantiated that pendulum values can be coordinated with film viscosity measurements. Using a special viscosimeter developed by Houwink,[17] Konig illustrates his data by viscosity-time curves which indicate that films become dry when their viscosity reaches 10 million poises. Data are presented up to 10^{11} poises, considerably below the limiting viscosity for solid materials, 10^{13} poises. No statements are made, however, on the relationship of these measurements to the presence or absence of tack. By way of contrast, Parker and Siddle,[18] state that the

[14] E. G. Herbert, "Method of Testing the Hardness of Metals and Other Materials," U. S. Patent No. 1,608,655.

W. J. Walker, "The Pendulum Hardness Tester," *The Engineer*, April 13, 1923, pp. 390–391, and June 29, 1923, pp. 686–687.

[15] P. B. Cochran and H. J. Graham, "Characteristics and Treatment of Insulating Varnishes," *Industrial and Engineering Chemistry*, Vol. 20, pp. 698–701 (1923).

[16] W. Konig, "Physical Examination of Drying Process in Paint," *Korrosion und Metallschutz*, Vol. 16, pp. 344–351 (1940).

[17] R. Houwink, "Physikalische Eigenschaften und Feinbau von Natur und Kunstharzen," p. 26 (Leipzig) (1934).

R. Houwink, "Chemie und Technologie der Kunstoffe," p. 164 (Leipzig) (1939).

[18] R. C. Parker and F. J. Siddle, "The Hardness of Paint and Varnish Films," *Journal of the Oil and Colour Chemists Assn.* (London), Vol. 21, pp. 360–390 (1938).

pendulum values have very limited significance when their connection with drying time departs from a linear relationship. The very high values obtained with certain films after 3 to 4 days' aging are claimed to bear no relation to the true hardness of these films. In any case, the commercial use of the pendulum type instruments is not practicable because of the necessity of several instruments and trained operators.

Low-Pressure Contact E[illegible]ments:

Sanderson Drying Time Meter.—The brush-point data obtained by observer No. 2, Table IX, are roughly equivalent to the average set to touch times for all of the varnishes except B. Observer No. 1's data show more reversals. The tap points obtained by observer No. 2 are in rough agreement with the finger-touch data with respect to the order of attaining the tack-free state, although the end points for all of the varnishes, particularly A and B, are much longer than the finger-touch averages. The tap-point data submitted by observer No. 1 show no differentiation and bear no relation to the finger-touch averages. This observer remarked that it might have been desirable to allow the varnishes to dry 2 or 3 days before starting the apparatus in order to get reliable end points.

Rolling Ball Tester.—The data obtained by this device, Table IX, are believed to correspond more closely with the Sanderson meter than other instruments, since the rolling ball, weighing 21.5 g., exerts only a fugitive contact per millimeter of travel on the coated glass plate adjusted to a 40-min. angle of inclination for measurements of the final stage of drying. The distance of roll, 100 cm., corresponds to an average time of contact of only 0.006 sec. per millimeter of path, substantially equal to point contact (Table VI). Under these conditions of test, three of the six varnishes, A, B, and E, gave results for the tack-free stage that agree fairly well with the results of finger-touch observations, although varnishes C, D, and F gave the distinctly lower values of 24, 30, and 28 hr., respectively.

The foregoing data were obtained with a film applicator giving a path 2 in. wide and a wet film thickness of 0.0015 in. Under these conditions of measurement, the tack-free times were taken as the drying times corresponding to constancy in rolling time, within 0.1 sec., in the curves obtained by plotting rolling times (seconds) *versus* drying times (Fig. 4). It is probable that a greater degree of concordance with finger-touch averages for varnishes C, D, and F might have been possible if these touch readings had been made at controlled thickness. Thus, the tack-free value reported by Bradley for varnish F at 0.0015 in. wet film thickness (Table IV) is consistent with the rolling ball results shown in Fig. 3. It is probable also that intermediate points might have been obtained corresponding to the degree of film toughness given by the Federal dry hard criterion (Table III) if the tester had been operated at a higher angle of inclination corresponding to a "blank time" of 4.0 sec. on an uncoated runway. The present results were obtained at a 40-min. angle, corresponding to a 5.0-sec. "blank time" on glass.

Further Details on the Rolling Ball Tester.—The Rolling Ball tester represents an effort by the author to extend the principles developed by Wolff and Zeidler[19] to later stages in the drying-time cycle. These authors showed that a rolling ball apparatus can be readily adapted to accurate measurements of the viscosity increase of films in the early stages of the drying-time cycle. They used steel balls having a diameter of 3 mm., angles of inclination of 5 to 35 deg., and distances of roll of 4 cm. In this way, they found that the viscosity of bodied linseed oil and castor oil can be measured with considerable accuracy up to 200 poises. Overholt and Elm verified these conclusions in a study of the viscosities of methyl esters of several unsaturated fatty acids.[20] These authors found that when the glass plate was set to an angle of inclination of $22\frac{1}{2}$ deg., the rolling time in seconds over a 4-cm. path was equal to the viscosity in poises. The apparatus was calibrated with kettle-bodied linseed oil, the viscosity of which was determined with a vacuum plastometer.

In considering a possible extension of the principl[illegible] utilized by Wolff and Zeidler to later stages of the drying-time cycle, the author constructed a simple inclined plane plate glass apparatus with adhesive tape guides and a magnetic release for the steel balls. These trials showed that accidental contacts of the rolling ball with the masking tape guides did not slow up the ball sufficiently to cause radical departures of the measured times, taken with a stop watch, from the theoretical times of roll, calculated from the equation $t = \sqrt{\frac{2S}{\frac{5}{7}g \sin \theta}}$. This equation takes into account the moment of inertia of the ball as it rolls down the plane, t, the time in seconds for a distance S

[19] H. Wolff and G. Zeidler, "New Method of Determining Viscosity Changes of Films During Evaporation of Volatile Constituents," *Paint and Varnish Production Manager*, Vol. 15, p. 7 (1936); also *Paint Technology*, Vol. 1, pp. 387–388 (1936).

[20] J. L. Overholt and A. C. Elm, *Industrial and Engineering Chemistry*, Vol. 32, March, 1940, p. 387.

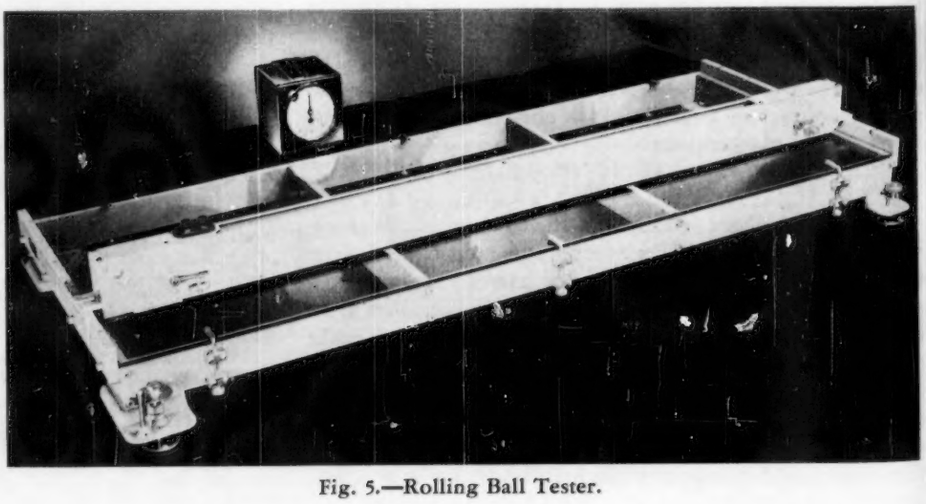


Fig. 5.—Rolling Ball Tester.

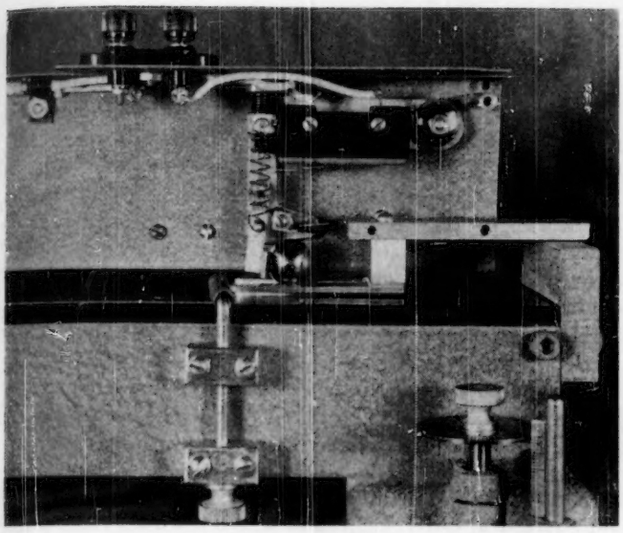


Fig. 6.—Starting Gate.

(100 cm.), the angle of inclination θ, and the gravitation constant, g. Steel balls exceeding 0.5 in. in diameter gave better agreement with the calculated times since their velocity was less affected by particles of dust, rolling friction, and departures of the surfaces (glass and steel) from ideal flatness and roundness, respectively.

The difficulty of securing reproducible results with this improvised apparatus emphasized the necessity of precise workmanship in the construction of a tester for laboratory use. The preliminary model designed by M. N. States of the Central Scientific Co., Fig. 5, incorporates the following features: (1) carefully selected plate glass, 18 by 48 in., mounted in a metallic frame supported by four leveling screws to control the angle of inclination; and (2) a portable time recorder comprising a release-stop mechanism actuated by microswitches. These switches start and stop, respectively, an electric timer which registers time intervals of 0.1 sec. with high accuracy. Figures 6 and 7 illustrate, respectively, the operation of the ball release and stopping mechanisms synchronized with the starting and stopping of the timer. The rubber rollers shown in these photographs are used to hold the plate glass in position on the steel frame and are so placed as not to impede the progress of the ball.

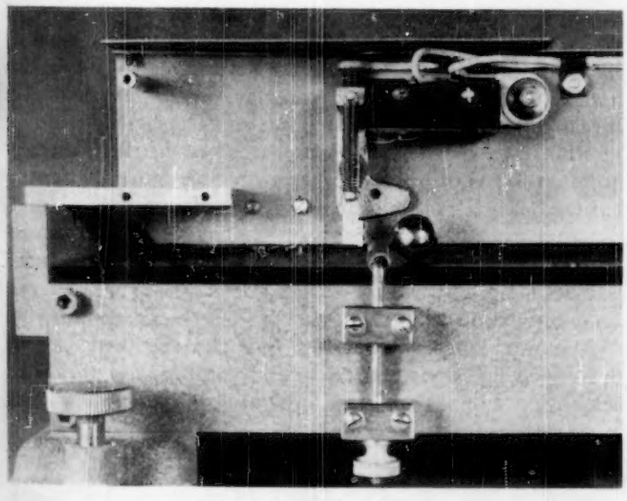


Fig. 7.—End Gate.

In making determinations, the portable timer, provided with metallic side walls to keep the ball on a 1 1/2-in. path, is moved from one varnish drawdown to another. The ball is released automatically at the top of the runway by pressing a button, which simultaneously starts the timer. Contact of the ball with a metallic baffle at the bottom of the path of travel stops the timer. The timer operates on 115 v. a.c. and makes one complete revolution in 10 sec., which happens to be the maximum time of roll that can be accurately measured when the plane is inclined to an angle of 40 min. As the coatings dry, the speed of roll approaches the "blank time" of 5 sec. characteristic of the speed of roll over an uncoated glass surface. In order to secure reproducible results, it is necessary that the plate glass be selected with great care and carefully calibrated for levelness. It is supported in a rigid frame with cross members to prevent sagging. The glass can be easily tested for its levelness by running blank determinations with the ball over the entire area. When adjusted for operation, the rolling ball tester should give results on dust-free surfaces that show a maximum probable error of ±0.10 sec. for ten consecutive observations.

While the present status of tests with the rolling ball tester indicates that this device is limited to measurements of the disappearance of tack, further studies at higher angles of inclination may show that intermediate stages of dry, comparable to the Federal dry-hard criterion, can be obtained. Also, extensive tests with heavier steel balls at lower angles of inclination may show that the device measures a factor analogous to disappearance of compression tack. Other tests with a 10-gal. length tung oil varnish indicate that this instrument measures a rolling time factor proportional to intrinsic surface hardness coincident with the removal of surface tack, since this varnish gave smaller constant rolling times than did the longer soft oil varnishes.

In a certain sense, the rolling ball tester measures the product of adhesion and pull resistance. Pull resistance, in turn, is a function of the film viscosity and yield value as shown by Green.[21] If the adhesion is zero, the product is zero and no tack exists even if the pull resistance is very high. In the case of varnish materials, it is probable that the viscosity reaches 10 to 200 million poises; but if the adhesion of a film having this high viscosity is negligible, pull resistance measurements cannot be made with the Tackmeter designed for printing inks. Since the duration of contact of the rolling element is practically negligible (0.006 sec. for a probable contact area of 1 sq. mm. for a rolling time of 6 sec. on a 100-cm. path), it is obvious that the rolling times are proportional to the adhesion or to frictional resistance forces developing between the test specimens and the material of which the rolling element is composed or both. The increase in time over glass is proportional to the integrated retardation due to frictional resistance, over the entire 100-cm. path. From this viewpoint, the criterion of "tack free" is minimum adhesion, or minimum frictional resistance, of the rotating element to the test film specimen over the 100-cm. path. When this condition prevails, the interfacial surface ten-

[21] Henry Green, Private communication, Interchemical Corp., New York, N. Y.

sion between the rotating element and the test specimen has reached a minimum value. Hence, it appears that if the rolling ball measures the progressive disappearance of frictional resistance between the steel surface (point contact) and the organic coating, it will measure tack-free times very accurately.

Conclusions and Suggestions for Further Work

This investigation has led to the following general conclusions which may be of value in planning further tests:

1. The present Federal Specification definitions and methods of test are unsuitable as a basis for intercomparison of the drying rates of varnishes by different laboratories, independent of whether determinations are made in regular laboratories or in air-conditioned rooms. However, these definitions appear to have definite value for single observers conducting measurements in duplicate or in triplicate. From this point of view, therefore, the definitions are satisfactory for independent observers who have established their own technique and reproduce this technique in all their measurements.

2. The results obtained by independent observers are more reproducible if the test applications are made on glass by means of a film applicator giving a wet film thickness of 0.0015 to 0.002 in.

3. The major cause of the lack of agreement in intercomparison tests by different observers is the wide variation in the personal equation which depends on pressure of the finger, duration of pressure and cleanliness of the finger. These factors affect the final results in a more critical way than changes in the environment (relative humidity, temperature, lighting conditions, air circulation).

4. Greater clarity is needed in the conception of "surface tack" (stickiness) and the relationship of this property to high pressure or "compression tack." The high values reported for the dry hard-tack-free stage indicate that the majority of the eleven collaborators used very high pressures in determining this characteristic. The wide variations reported are undoubtedly due to the absence of control in the amount of finger pressure used and duration of the pressure. In general, it appears that the majority of the collaborators touched the specimens lightly when wet and increasingly hard as the successive stages of drying were reached.

5. None of the instruments studied give complete information on all aspects of the drying of surface coatings, but rather specialized information useful in understanding one phase, or possibly two phases of the process of film solidification. For example, the machines provided with high-pressure contact elements (Parks Dry-O-Graph and Drying Time Recorder) measure film firmness at a stage roughly comparable to the Federal dry hard criterion, but cannot detect surface tack or compression tack. The pendulum type instruments, (Walker-Steele beam and Sward rocker arm) likewise provide no information on tack, but apparently measure a characteristic associated with the ultimate conversion or maximum hardness obtained on prolonged drying. The rolling ball tester measures surface tack quantitatively, but the end points recorded do not necessarily correspond to the disappearance of compression tack. The Sanderson meter measures a preliminary film firmness characteristic intermediate between dust-free and dry hard, but does not give reliable indications of surface tack, probably because of the penetrating quality of the sand particles. Amorphous silica might prove more satisfactory in determining the tap points.

6. No satisfactory method has been developed to date for measuring the disappearance of "compression tack," represented by the average end points of 67 to 76 hr. given by the eleven collaborators for the final stage of drying.

Although the foregoing conclusions are, of necessity, qualitative in nature, they may serve as a basis for developing new test methods associated with the practical requirements of surface coatings for specific purposes. Film properties that change during the drying cycle are viscosity, surface tack, compression tack and surface hardness. Viscosity is evidently the most important factor, since practical criteria can be most readily associated with the attainment of definite viscosity levels. Thus, "set to touch" corresponds to a film viscosity which is sufficient to prevent flow and is identical with the "wet edge time" for brushing materials, absence of "orange peel" for spray materials and lack of sagging for dipping materials. "Dry hard and firm" corresponds to a higher film viscosity that permits light handling and perhaps rubbing and polishing. "Print free," usually considered the final point in the drying cycle, corresponds to a still higher viscosity and represents the time of dry necessary to permit stacking, wrapping, and packing of finished articles without the danger of printing. From this viewpoint, the presence or absence of surface and compression tack at the second and third viscosity levels has no bearing on film viscosities, expressed as poises, or print resistance values.

The foregoing tentative definitions indicate that if the degree of firmness of a film is directly proportional to its viscosity, an instrument designed to measure film viscosity as a function of drying time would be highly desirable. Houwink[22] has described briefly several plastometers designed to measure viscosities in the range of 10^4 to 10^{11} poises, which should adequately cover the range of interest to the consumers of surface coatings.

Alternately, the development of a satisfactory print testing device, consisting of a convenient adaptation of the well-known cheese cloth 2-lb. weight test described by Gardner,[23] may be found more advantageous than a film viscosimeter, since this device may permit simultaneous measurements of compression tack. Thus, a convenient modification of the technique described in the February 10, 1943, issue of Federal Emergency Spar Varnish Specification E-TT-V-121a might be developed to provide simultaneous measurements of print resistance and compression tack. This new method for measuring "after-tack" utilizes a 6.28-lb. weight which exerts a pressure of 2 psi. on manila paper placed in contact with the varnish.

Assuming that satisfactory quantitative tests can be developed for print resistance and compression tack, the remaining film properties associated with drying rate,

[22] R. Houwink, "Elasticity, Plasticity and Structure of Matter," Cambridge University Press, p. 20 (1937).

[23] H. A. Gardner, "Paint, Varnishes, and Lacquer," Ninth Edition, p. 119 (1939).

surface tack and surface hardness can be measured with the rolling ball tester and Sward rocker arm, respectively.

Because of the complicated interrelationship of film properties related to drying (viscosity, compression tack, surface tack, and surface hardness), it seems that definite progress can be made by visualizing surface coatings as plastic solids whose resistance to an applied force can be expressed by the equation $D = \frac{1}{\eta}(\tau - f)$, where D designates the velocity of flow, η the viscosity, τ the applied stress or force, and f a quantity proportional to the yield value.[24] When a film becomes "print resistant," the yield value is zero and this equation becomes $D = \frac{1}{\eta}\tau$.

Visualization of paint films in terms of plastic solids may also be useful in clarifying the relationship of compression tack to the deformation of the films at the time the tests are made. Such considerations may show that the adhesion or sticky characteristics developing on removal of a weight should not be confused with genuine surface tack. At any rate, some attempt should be made to understand the relation between surface tack and compression tack. This might be done by ascertaining whether surface tack can be regenerated by application of heavy weights to a film that previously became tack free by a method using low-pressure contact elements. Such tests might tend to reinforce the conclusion that genuine tack is a surface phenomenon, capable of measurement by light-pressure contact elements, and that compression or pressure, tack is a function of plastic flow. English investigators in attempting to unify the concept for tack for the printing ink, paint, adhesives, and plastics trades, concur in the view that tack is identical with surface stickiness.[25] These investigators have admitted the possibility of "tacky solids" analogous to print-free varnish films which possess residual tack, but have not stated whether the amount of tack present should be estimated by low-pressure or high-pressure contact elements.

Summarizing, it appears that the formulation of new drying time definitions should take cognizance of four primary stages of film firmness (viscosities) which can be chosen to correspond with practical requirements. The secondary characteristics of surface tack, pressure tack, and surface hardness can then be associated with the four stages of drying as indicated by Table X.

It is believed that print test definitions can be formulated on a quantitative basis after collaborative work has been undertaken on the minimum weights and times of contact necessary for determination of factors proportional to the four primary stages of viscosity or film firmness noted in Table X. Independent determinations of viscosity will be made with a paint film viscosimeter, or equivalent instrument, if available. The ranges in film viscosities (poises), or quantitative print-resistance values selected in these tests should be considered absolute primary characteristics for all types of surface coatings, while the amounts of surface tack, pressure tack, and surface hardness prevailing at each of these levels undoubtedly will be found to vary with the types of products tested. Thus, it is conceivable that such widely different products as house paints, long oil synthetic paints for exterior equipment, exterior gloss enamels, floor enamels, interior gloss enamels, and flat and eggshell paints might show widely different tack and surface hardness properties (secondary characteristics) at the same viscosity levels. The speed with which these various finishes arrive at predetermined viscosity levels, and the degree and kind of tack present and surface hardness attained, should serve to characterize these materials adequately from a drying rate standpoint.

TABLE X.—TENTATIVE ANALYSIS OF VARNISH-DRYING RATE PROPERTIES AT A STANDARDIZED DRY-FILM THICKNESS.

Primary Characteristics, Viscosity Levels (Film Viscosimeter or Quantitative Print Test)	Secondary Characteristics (Various Methods for Surface Tack, Pressure Tack, and Surface Hardness)	Practical Definitions
1. (Very light weight) 10^3 to 10^4 poises	Amount of tack (both kinds) too great for accurate measurement	*Set-to-touch;* absence of flow (wet-edge time limit, no orange peel, no sagging)
2. (Light weight) 10^5 to 10^6 poises	Surface tack—any prescribed value Pressure tack—any prescribed value Surface hardness—usually very low	*Dry hard;* dry to handle (light rubbing and polishing)
3. (Heavy weight) 10^7 to 10^8 poises	Surface tack—shall be absent Pressure tack—any prescribed value Surface hardness—any prescribed value	*Dry hard-tack free* (drying sufficient for stacking, wrapping, and packing of finished articles with no danger of printing)
4. (Very heavy weight) 10^9 to 10^{10} poises	Surface tack—shall be absent Pressure tack—shall be absent Surface hardness—maximum value after baking or prolonged air drying	*Bone dry* (no printing with weights exerting up to 10 psi.; surface hardness very high for refrigerator and automotive finishes)

In developing new test methods, an effort should be made to obtain film viscosity or print resistance data that are independent of the presence or absence of both kinds of tack. Likewise, a study of methods for determining secondary drying characteristics should differentiate surface properties and pressure tack from plastic flow due to the different weights applied at the four stages of film viscosity. The results obtained should permit conclusions as to whether pressure tack is a bonafide characteristic or a composite function of plastic distortion and genuine surface tack. In utilizing instruments designed to measure secondary characteristics on a quantitative basis, the relationship of practical requirements to arbitrary ranges in film viscosity, expressed as poises, will be more clearly understood.

Lastly, in formulating definitions for the four stages of film firmness (viscosities), care should be taken not to convey the idea that these stages represent real points of discontinuity in the drying-time cycle, but rather arbitrary viscosity ranges that coincide fairly well with practical requirements. It must be remembered that drying is a continuous process, and that the stages selected for measurement should not be interpreted as points of discontinuity which have basic physical significance.

[24] R. Houwink, "Elasticity, Plasticity and Structure of Matter," Cambridge University Press, pp. 3–5 (1922).

E. C. Bingham, "Fluidity and Plasticity," McGraw-Hill Book Co., New York, N. Y.

[25] British Rheologists' Club and Printing and Allied Trades Research Assn., "Tack and Sticky Materials," *Nature*, Vol. 150, No. 3796, pp. 159–160 (1942).

1944 Foundry Congress in Buffalo; A.F.A. Staff Officers

THE Board of Directors, American Foundrymen's Association, have announced the Third War Production Foundry Congress to be held in Buffalo, N. Y., the week of April 25, 1944. The technical meetings and the exhibit displays will be in Buffalo's Memorial Auditorium. Previous to this forty-eighth A.F.A. Annual Meeting the foundrymen met in Buffalo twice—once in 1912, and prior to that in 1901.

Another news note of considerable interest to many A.S.T.M. members is the election of R. E. Kennedy as A.F.A. Secretary, with C. E. Hoyt, Treasurer. The offices of Executive Vice-President and Secretary were combined —thus Mr. Kennedy becomes the administrative head of the Association. He has had a wide foundry experience and has been affiliated with A.F.A. Headquarters since 1921; Technical Secretary since 1925. Mr. Kennedy represents the A.F.A. membership in the Society (which dates from 1898) and he has aided in many of the A.F.A.-A.S.T.M. cooperative projects.

National Bureau of Standards

RECENTLY received is a copy of the report outlining the activities of the National Bureau of Standards for the fiscal year 1942. There is hardly any phase of the Bureau's work which is not of interest to a large group of the A.S.T.M. members and some may wish to procure copies of the condensed report. It is believed the Bureau will be glad to send a copy on request. One notes that the Bureau has been able to expand some of its important activities and that needed new facilities are being made available including a new materials-testing laboratory. As of June 30, 1942, the staff totaled about 1700, a considerable increase over the previous year.

Much activity has been devoted to confidential problems connected with the war effort which is evident also from the fact that the Bureau was awarded the Navy "*E*" Pennant for working successfully on problems submitted by the Navy Ordnance Department. There are numerous references to A.S.T.M. throughout the report, for the Bureau cooperates in many phases of A.S.T.M. work and its representation on technical committees is in excess of 300. It holds the chairmanship of upwards of 35 committees and the secretaryship of 13. Another indication of the Bureau's interest is the fact that G. E. F. Lundell, was A.S.T.M. President in 1941–1942 and P. H. Bates is now Vice-President.

Building Materials and Structures:

In connection with these notes about the Bureau, it is pertinent to record the receipt of Report BMS 100, Building Materials and Structures, which covers relative slipperiness of floor and deck surfaces. On several occasions notes have appeared in the BULLETIN on some of the 100 specific projects covered and also comments on the great value of the endeavor as a whole. Lists of the projects can be obtained from the Superintendent of Documents. A list of the reports and copies of individual items, prices ranging from 5 to 20 cents each, can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

THE ACCOMPANYING illustration first noted in the September issue of *The Crucible* is a very striking visual portrayal of a fact which is apparent to all technologists and is appreciated to an increasing extent by the public, namely, the direct relation between science and the technical man and our war effort. The picture is by a Westinghouse photographer, Charles Nelson, who was in the laboratories on another assignment when he noticed that the shadow cast by some chemical equipment resembled a gun. Result, an illustration that needs no words to tell the story of war research. With a shadow, Nelson has shown how the man in the laboratory helps the man in the front lines.

In using this illustration from the September *Crucible* it would be in order to extend congratulations to Messrs. H. H. Craver, Pittsburgh Testing Laboratory, and E. H. McClelland, Carnegie Library of Pittsburgh, Editor and Associate Editor, respectively, for this outstanding issue which was dedicated to the 106th Meeting of the American Chemical Society.

Essential Conservation for All of US

A COMMUNICATION to association executives signed jointly by Donald M. Nelson, Harold L. Ickes, and Joseph B. Eastman stresses the necessity of conservation during the current decisive stage of the war effort. The fields in which this is considered most important include coal, oil, gas, electricity, water, communications, and transportation. Information with the letter gave reasons why conservation was so important; for example, in the field of communications war has created the greatest demand for telephone communications ever experienced. Every one should understand the extreme necessity of all possible conservation.

Perhaps the essential elements to keep in mind are, first, the tremendous saving which results when only a small item such as a bit of water or electricity is multiplied by a few hundred thousand or million; secondly, in our democracy everyone should cooperate. Perhaps there is a third—not to be overly optimistic too soon!

A Method for Evaluating Performance in Service of Slow-Curing Asphalts*

By Joseph Zapata[1]

SYNOPSIS

A report is made of studies conducted in the field to determine the nature of the changes undergone by asphalts of the slow-curing type under service conditions. The changes found are correlated to results obtained with a heat test of the type used in A.S.T.M. Tentative Method of Test for Residue of Specified Penetration (D 243 – 28 T).[2] Systematic observations of mats in service are reported and correlated to laboratory tests. A practical application of the results that can be obtained with A.S.T.M. Method D 243 – 28 T is illustrated in connection with the control of characteristics which govern performance in service.

An examination of the available literature on asphalts of the slow-curing type (known among highway workers as road oils) will disclose a variety of reports on construction technique, some reports on laboratory studies of basic characteristics, but no reports or data correlating performance in service with laboratory tests of the nature found in commonly used specifications. The highway engineer if he has not had the experience and relies entirely on specifications of the "open" type may have to report at the end of the season that ". . . should have been a good job. For some reason or other, that whole mileage of, I believe, about twelve miles pot-holed very badly. We got all the scientific help at our command to determine what caused the failure, but we do not know yet what it was. . . ."[3] If he has had the experience, he will add to the "open" specifications one or more of the many tests that have been proposed as valuable control requirements. In this case, he may find himself accused of bias, of showing discrimination or prejudice against sources or manufacturers; he also may find that the products furnished him may be of the type which give unsatisfactory performance in service.

Recognizing the need for information on fundamental characteristics and behavior of slow-curing asphalts (many millions of gallons of these materials are used annually in Wisconsin alone), the State Highway Commission of Wisconsin in cooperation with the Wisconsin Alumni Research Foundation, sponsored an investigation on the properties and composition of asphalts of the slow-curing type.[4]

Study of a Mat in Service

One of the principal studies undertaken involved an examination of the changes undergone by the bitumen in a mat on one of the state trunk roads in Wisconsin. Samples, in sufficient number to give a representative average, were taken at intervals of a week for eight weeks and again after sixty weeks of service. The samples were extracted with benzol and the bitumen was recovered by means of a modification of the Abson method[5] (lower temperatures than those proposed by Abson for the recovery of asphalt cement were used). The percentage of bitumen in the mat samples and the viscosity and composition of the extracted bitumen were determined. The viscosity measurements were made with a rise in capillary viscometer and the composition was determined by means of a modification of Marcusson's method[6] with which asphaltenes, oily constituents, and resins were determined. The changes in composition, calculated on an ash-free basis, which took place during 60 weeks of service are shown in Fig. 1 taken from *Bulletin* 86.[4] The figure shows data for the top 1/4 in. and for the bottom portion of the mat. The points marked "100 penetration residues" and "20 penetration residues" represent the composition of residues of the indicated penetrations from the bitumen extracted from the 60-week-old mat. The data show that the change in compositions follows a straight line drawn from the apex of the 100 per cent oily constituents. The position of the line is taken to indicate that the changes in composition taking place during service were due mainly to evaporation.

The changes in viscosity which took place during the period of 60 weeks are shown in Fig. 2, also taken from *Bulletin* 86.[4]

The bitumen content of the mat was found to decrease with age: the initial bitumen content of the upper 1/4 in. of the mat was found to be 4.70 and, after 60 weeks of service, 3.93 per cent.

Simultaneously with the mat studies, laboratory accelerated weathering tests were made using cycles of ultraviolet light, moisture, freezing and thawing, and dry air.

The aforementioned studies led to a number of conclusions of which the following are pertinent to this report, for others see *Bulletin* 86:

Evaporation of the oily constituents present in the slow-curing asphalt was the main cause for the changes in composition and consistency shown by the bitumen extracted from the mat in service.

One of the important causes of failure of a mat in service is the loss of bitumen caused by evaporation, absorption, and washing away by repeated rainfall.

Accelerated weathering tests using ultraviolet light do not give a true indication of the changes occurring in service because such tests stress oxidation over evaporation changes.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

* Presented at Forty-sixth Annual Meeting, Am. Soc. Testing Mats., Pittsburgh, Pa., June 28–July 2, 1943.

[1] Chief Chemist and Assistant Materials Engineer, Bituminous Laboratory, State Highway Commission of Wisconsin, Madison, Wis.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 948 (1928); also 1928 Book of A.S.T.M. Tentative Standards, p. 528.

[3] *Proceedings*, 1939 Montana National Bituminous Conference, Montana State Highway Dept., p. 284.

[4] A. J. Hoiberg, O. A. Hougen, and J. Zapata, "The Properties and Composition of Asphalts of the Slow Curing Type," *Bulletin*, University of Wisconsin, Engineering Experiment Station, Series No. 86, October, 1939.

[5] Gene Abson, "Method and Apparatus for the Recovery of Asphalt," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 704 (1933).

[6] M. Rosumny and A. DeRossett, *Roads and Streets*, Vol. 81, No. 12, p. 38, December, 1938.

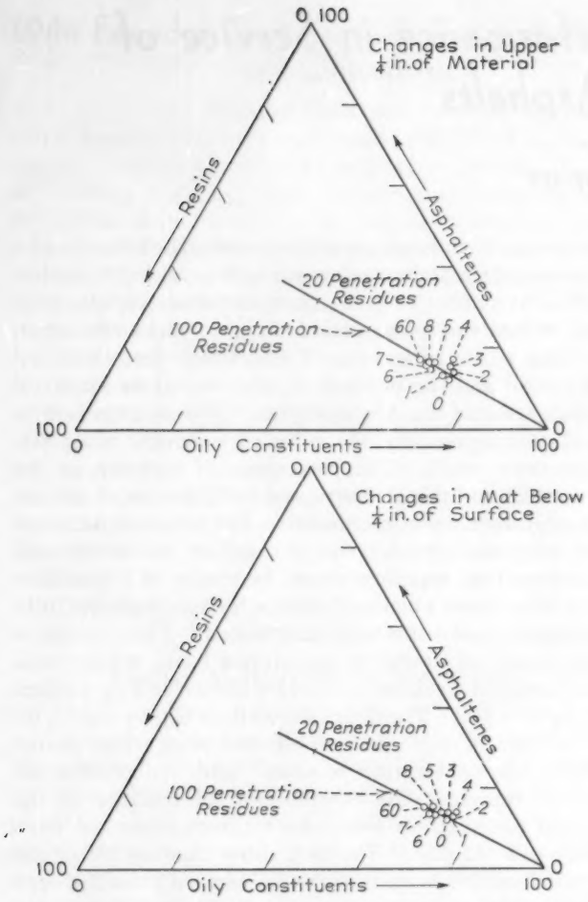


Fig. 1.—Composition Changes in La Valle Road.
Numbers indicate service time in weeks. Composition determined by laboratory analysis, ash-free basis.

Results obtained in studies of other mats containing slow-curing asphalts meeting the same specifications but from different source and of different type have confirmed the aforementioned findings.

Changes in Composition Undergone by Slow-Curing Asphalts When Subjected to Laboratory Tests

Marcusson's modified method for determining composition expressed in percentages of asphaltenes, oily constituents, and resins was used for measuring changes in asphalt samples exposed to heat or ultraviolet light tests.

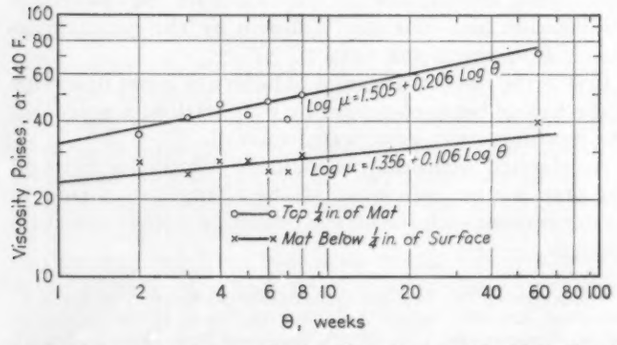


Fig. 2.—Viscosity Changes During Weathering of La Valle Road.

The exposures were made on thin films in order to retain a ratio of surface area to volume as would be found in the mat. Figure 3 gives the results of tests made on two different types of asphalts that met the same specifications. Crudely classified, sample marked "oil A" is of asphaltic base, while "oil B" is of semiasphaltic base. The two oils, however, show the same trend; namely, changes which take place during heating are due to evaporation of the oily constituents, while changes undergone during exposures to ultraviolet light show gains in asphaltene contents which cannot be attributed to evaporation. It appears to be evident, therefore, that a heat test involving evaporation losses does simulate changes undergone in service, especially if such changes are not complicated by other factors such as washing away, absorption of the bitumen by the aggregate, insufficient amount of bitumen in the mix, etc.

The use of films makes difficult if not impractical the examination of residues for ductility, softening point, or other characteristics which might be considered to be of value in a residue exposed to service conditions. Fortunately, the investigation sponsored by the State Highway Commission and the Alumni Research Foundation disclosed that in A.S.T.M. Method D 243 – 28 T the dominant changes taking place in a slow-curing asphalt under test are due primarily to evaporation. The following quota-

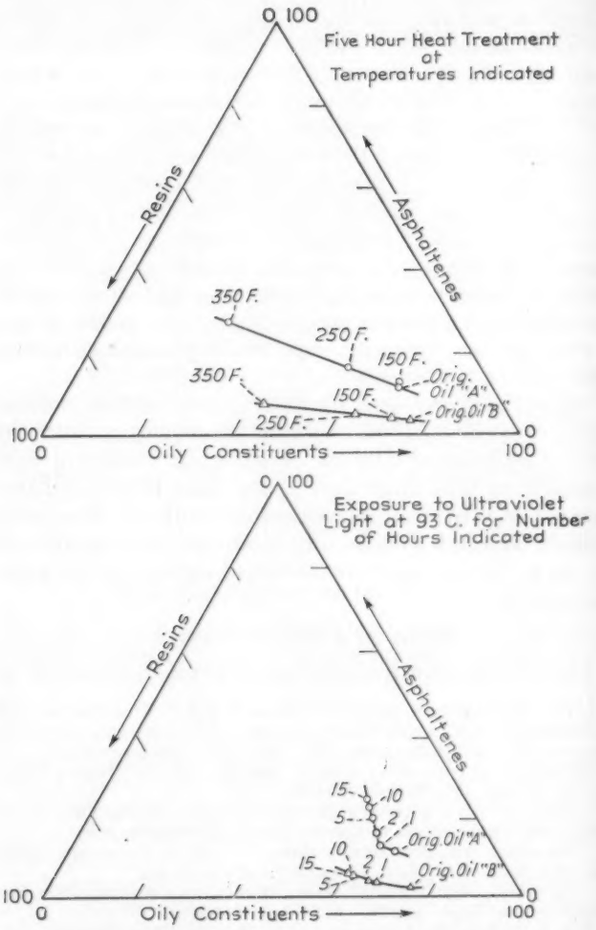


Fig. 3.—Composition (Laboratory Analysis) After Heat and Ultraviolet Light Treatments of Oils A and B.

tion from *Bulletin* 86 is offered as evidence to establish the use of the method in connection with the work reported herein; for a more complete discussion the reader is referred to *Bulletin* 86:

"The authors contend that vaporization of the volatile oils present in the original asphalt is largely responsible for the loss in weight during the test, and that changes due to condensation, oxidation, and cracking are usually negligible. This statement is based upon the evidence that the ratio of resins to asphaltenes does not change appreciably during the test. This was established by analysis of the asphalt and by measurement of penetration temperature susceptibilities during the course of evaporation. When composition of the residue during the course of evaporation was converted to the solvent extraction basis and then plotted on the triangular diagram, the changes in composition were found to proceed in a nearly straight line away from the apex of 100 per cent oily constituents. This indicates that the ratio of resins to asphaltenes remains constant and hence the only change taking place is by evaporation of volatile fractions in the oily constituents. Furthermore, the penetration temperature susceptibilities remained constant during the reduction, which occurrence confirms the aforementioned conclusion since this property depends upon a constant ratio of resins to asphaltenes and does not change appreciably with changes in oily constituents."[7]

A.S.T.M. Method D 243 – 28 T in addition to paralleling losses undergone in service makes available residues which can be used for other tests.

Residues of similar nature can also be obtained by means of A.S.T.M. Method of Test for Residue of Specified Penetration (D 243 – 36),[8] however, the former method is preferred because of the shorter time required to run the test: a saving of 50 per cent in time is not unusual and becomes a factor of considerable importance in reducing asphalts which would require 20 hr. or more to reduce by means of the second method.

Practical Application of the Results of A.S.T.M. Method D 243 – 28 T

Observations of the service performance of mats throughout Wisconsin have revealed that some asphalts, from different sources, have consistently produced mats which have rendered service considered to be satisfactory by maintenance engineers. One of these asphalts was selected for the study of its residue obtained with the use of A.S.T.M. Method D 243 – 28 T. Portions of a sample of the asphalt were heated for different periods and graphs were plotted to show the relation between time of heating and percentage of loss and time of heating and changes in consistency, Fig. 4. The data show that the consistency changed at a rate which would bring it to 100 penetration in 165 min. The data in Fig. 1 indicate that at the end of 62 weeks residues may have consistencies much softer than that corresponding to 100 penetration; therefore, it does not appear to be essential to reduce to this penetration; reduction to 150 penetration consistency would be as convenient and for some asphalts this consistency might be closer to the consistency of the residue left in the mat after a period of service. The consistency of 100 penetration was selected as the end point in view of common specification requirements which express percentages of residues in terms of 100 penetration.

Graphs such as those shown in Fig. 4 could be used to make comparisons among asphalts from various sources.

[7] J. P. Pfeiffer and P. M. van Doormaal, *Journal*, Institute of Petroleum Technologists, Vol. 22, p. 414 (1936).

[8] 1942 Book of A.S.T.M. Standards, Part II, p. 485.

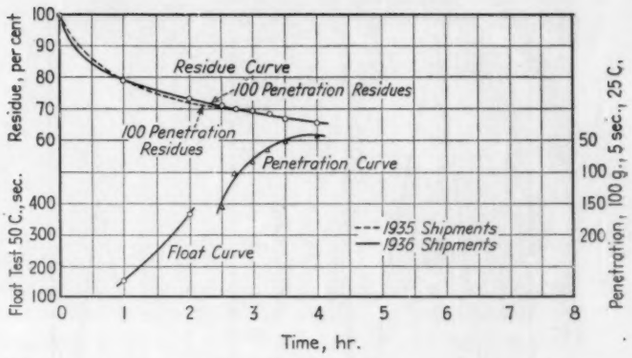


Fig. 4.—Changes in Consistency and Percentage of Residue Undergone by a Slow-Curing Asphalt When Heated According to A.S.T.M. Method D 243 – 28 T.

However, it has long been a matter of contention that the testing of bitumens alone is not sufficient to represent what may be expected of a road mix containing them together with aggregates of various sizes and types. In view of this contention, which is reasonable and logical, residues were first obtained using A.S.T.M. Method D 243 – 28 T and then compared by means of standard mixes made into standard briquets. The residues were obtained by heating samples of slow-curing asphalts of all the types and from all the sources from which shipments have been made for state work in Wisconsin in the past. Four periods of heating were selected to correspond to as many fractions of the period of 165 min., which time was required by the selected asphalt of satisfactory service performance to reach consistency of 100 penetration. The residue from each period of heating was mixed with aggregate consisting of glacial drift sand common in Wisconsin and having a gradation similar to that found in a road mat (a laboratory selected gradation was not used because it does not take in account degradation in service). Standard briquets were made for compression and resistance to impact tests. A number of precautions were taken in the making of the briquets: the percentage of each size in the gradation of the aggregate was weighed individually for each briquet, the percentage of bitumen was calculated on a volume basis and corrected for the percentage loss, the mixes and the briquets were made in accordance with minutely prescribed procedures and with the use of specific temperatures and mixing times. The briquets were tested in accordance with the principles which Vokac outlined in his paper presented before the Society in 1936.[9]

The compression test was selected because it was felt that other mechanical tests now in use do not furnish substantial evaluations of performance in service. For example, Hubbard-Field and triaxial loading tests are apt to show widely scattered values which are not amenable to the making of correlations. The compression test for bituminous mixes is not generally recognized as yet, but Vokac's work indicates that it is a valuable test; in addition it is convenient to make, its results are relatively simple to handle, and with care reasonably good duplications can be obtained.

Compression test graphs do not disclose the entire nature of the mixes. For example, some mixes showed ap-

[9] Roland Vokac, "Compression Testing of Asphalt Paving Mixtures," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 552 (1936).

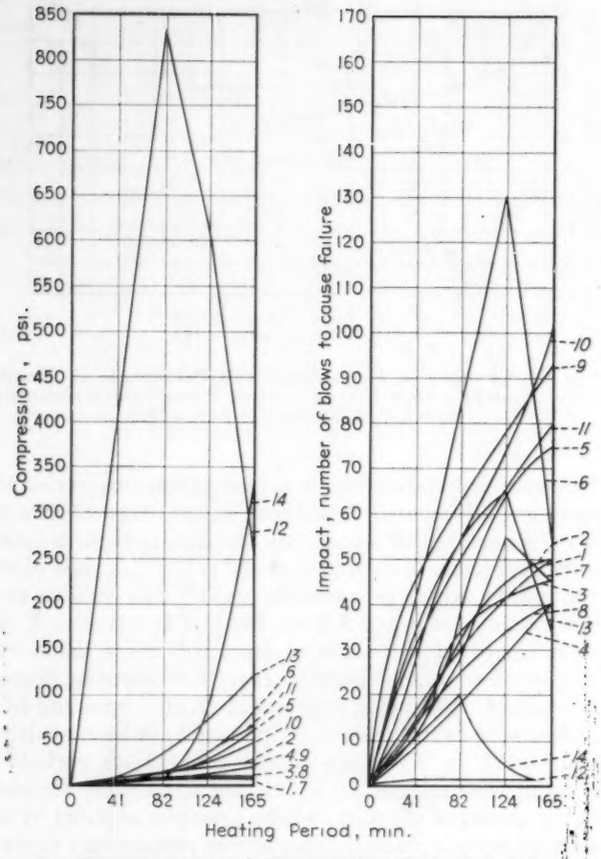


Fig. 5.—Compression and Impact Test Data for Laboratory Mixes Made with Asphalts of the Slow-Curing Type.

preciably high values in compression, thus making it appear that the asphalts in those mixes had desirable properties; actually the mixes were sufficiently friable to come apart unless care was taken in handling them. An impact test was used, therefore, to supplement the compression test. It consisted in dropping a steel ball weighing 1 lb. from a height of 30 in.; the briquets were mounted on a soft white pine base selected for uniformity in texture and degree of hardness of the surface. The number of blows required either to shatter, check, or crack the upper surface of the specimen was considered to be an index of resistance to impact. Since the study concerned itself primarily with the behavior of the bitumens, all tests were made at room temperature (73 to 77 F.).

The asphalts used met the following specifications, which will be recognized to be of a type commonly used:

	Group 1	Group 2
Water, per cent, not more than	0.5	0.5
Viscosity, Saybolt Furol, 140 F.	300 to 600	700 to 1000
Loss on heating, 163 C., 50 g., 5 hr., per cent, not more than	5	4
Flash point (Cleveland cup), not less than	200 F.	200 F.
Percentage of residue, 100 penetration, not less than	75	80
Ductility of residue, 77 F. (5 cm. per min.), cm., not less than	100	100
Bitumen soluble in CCl_4, per cent, not less than	99.5	99.5

Some of the asphalts were found to meet fluidity factor, low temperature ductility, and Oliensis spot test requirements, while others had characteristics of the nature covered by coagulation and sulfur tests.

Figure 5 shows typical results obtained with the compression and impact tests: the figures on the curves refer to the laboratory number of the samples. As the curves indicate, samples Nos. 1 and 7, 3 and 8, 4 and 9 had identical characteristics in compression. A study of this type of data led to the finding that laboratory mixes could be grouped into three distinct ranges: mixes of a highly plastic condition which can be suitably described as "mushy," mixes ranging from a slight plastic condition to a slight hard condition, and friable mixes. The first is typified by low strength in compression with some resistance to impact; the second by higher strength in compression with the same or higher resistance to impact as group 1, while the third has a high resistance to compression but low or no resistance to impact.

The most striking finding made was that some asphalts which met rather well the requirements for fluidity factor, low temperature ductility, and spot test produced mixes of the highly plastic nature, while other asphalts which had the same values for the tests mentioned produced mixes of the second group; some asphalts which met the given specifications, and which were thus assumed to be like the other asphalts tested, produced mixes of the third group.

Other distinctive characteristics were found: asphalts falling in the first group were found to be, in general, low in specific gravity, low in asphaltene content, and low in resistance to stripping (the test was made using Nicholsol's procedure).[10] Asphalts in the second group were of higher specific gravities, higher asphaltene contents, and higher resistances to stripping. In the third group, the asphalts were found to be characterized by high specific gravities, high asphaltene contents, and higher resistance to stripping.

The most important difference shown by the asphalts in the three groups was the difference in time required to reach consistency of 100 penetration when tested according to A.S.T.M. Method D 243. Asphalts of the first group required over 5 hr.; of the second, between 1 and 5 hr.; and of the third, less than 1 hr.

Correlations with Performance in Service

Although the aforementioned findings appeared to be important and significant, their value was not accepted without evidence furnished through performance in service. Observations and studies of mats in service are difficult to make on account of the number of factors that have to be considered. Therefore, to place them on an "average basis" these observations and studies were carried out in two ways: mats in selected locations, chosen on the basis of type of traffic, type of aggregate, base conditions, drainage, and method of construction, were studied in close detail; several mats were observed through the State road system for such behavior and conditions as appeared in the selected mats. It will be shown later in the report, that the selected mats gave positive evidence which correlated very well with laboratory findings. The results shown by these mats were duplicated to a large extent by the other mats. As it might be expected, in some instances the results were more definite and clear than in others, but on the whole the results that will be described

[10] Victor Nicholson, *Proceedings*, Association Asphalt Paving Technologists, January, 1932, p. 43.

Fig. 6.—The Road Before Treatment.
Before building the mat, fresh aggregate, having a proportioned gradation, was placed on the gravel traffic bound base.

Fig. 7.—The Mat Was Built in June, 1940.
This picture was taken a year later. The mat is about 1.75 in. thick and has an average bitumen content of 4 per cent. Note the stripping of the aggregate on the surface and the concentration of bitumen as indicated by the black spots. This is one of the best sections of the road.

Fig. 8.—A Few Weeks After Treatment, the Road Began to Turn Gray.
This condition was due to the stripping of the aggregate. A year after treatment the contrast shown in the photograph was noted. The dark portion is a bituminous mix made with a different asphalt and used for patching. The patch was about six months old when the picture was taken.

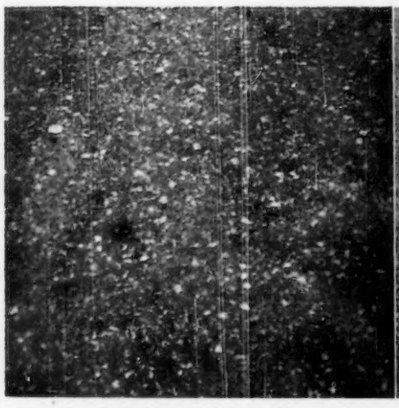


Fig. 9.—Typical of Mats Containing Bitumen of the Type Used Here Is the Development of Small Pits Due to the Loosening and Pulling Away of Aggregate Particles by Traffic.
The mix begins to show stripping and concentration of bitumen as shown by the black specks. This appearance is found over the entire mat.

Fig. 10.—Early in May, 1941 (the Mat Was Laid in June, 1940), Shortly After the Snow Had Disappeared from the Ground and the Sun Began to Warm the Surface, These Rather Large Black Spots Began to Appear; at First They Seemed to Be "Droppings" from Trucks Carrying Bituminous Mixtures.

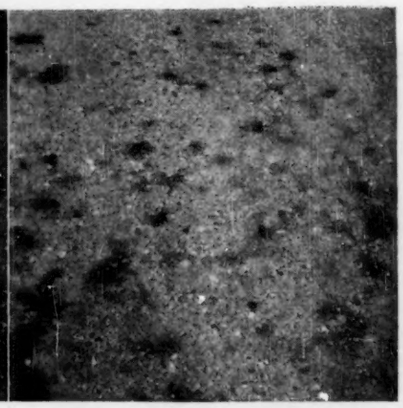


Fig. 11.—The Spots Began to Spread Aided by the Smearing Action of Traffic.
Note the fine cracks through which the bitumen extruded. The surface shows a large amount of stripping and incipient ravelling.

Fig. 12.—Later in May, 1941, the Road Surface Began to "Bleed" and Get Marked as the Picture Shows.

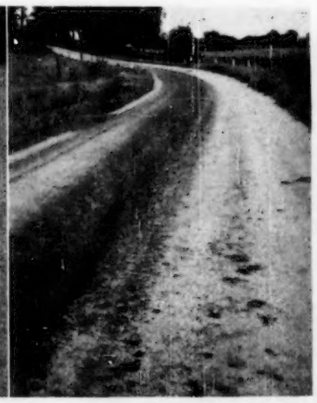


Fig. 13.—By the Middle of June, 1941, Many Sections of the Road Showed a Condition Similar to This.
On curves especially, the surface was dangerously slippery in all kinds of weather.

Fig. 14.—The Mat in May, 1941.
This condition is apparent in its better portions. The aggregate particles are loosely held in place, although on casual examination the mat appears to be hard. Note the small pits from which the aggregate particles have been pulled away.

Fig. 15.—In Places the Mat Is Ready to Disintegrate; in an Attempt to Save It a Heavy Seal Coat of RC Material Was Used.

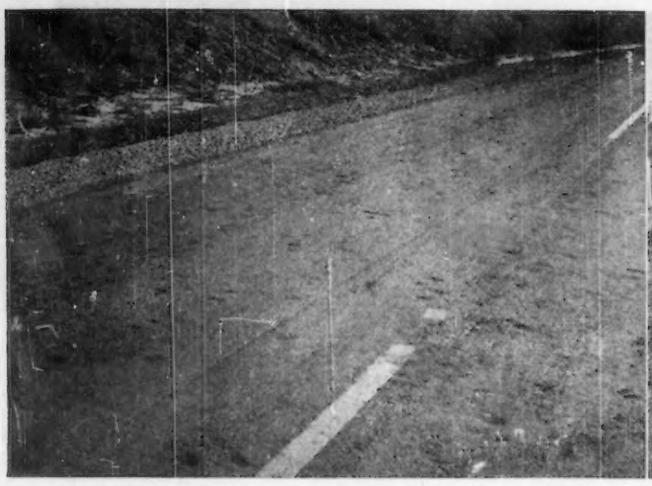


Fig. 16.—The Picture Was Taken When the Mat Was $3\frac{1}{2}$ Weeks Old.

Fig. 17.—Four-Months-Old Mat.
Note the contrast with an older portion of the road mat which was built with asphalt from a different source.

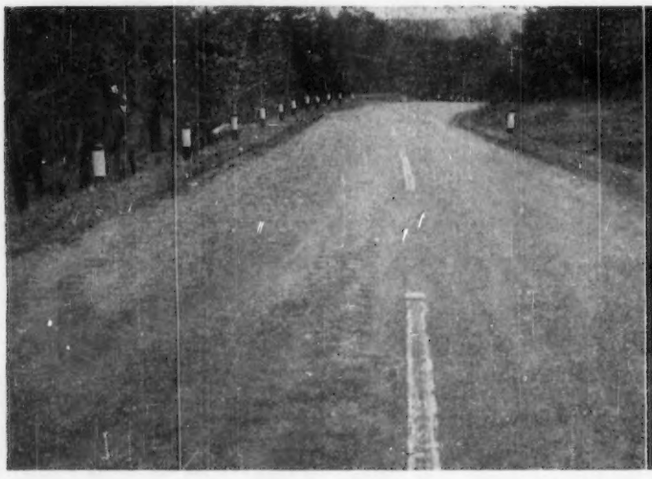


Fig. 18.—A 28-Months-Old Mat.
The asphalt used in this mat came from the same source as the asphalt which was used as the standard in establishing the periods of heating used in the study reported herein.

Fig. 19.—The Aggregate on the Surface Has Been Stripped by Abrasion; No Stripping Is Noticeable Inside or at the Base of the Mat.

Fig. 20.—The Mat Is Becoming Hard and Brittle; the Hardening Is More Apparent at the Edge of the Shoulders and on the Immediate Surface of the Mat.

TABLE I.—CHARACTERISTICS OF ASPHALTS USED IN BUILDING THE MATS SHOWN.

Tests	Fig. 7	Fig. 16	Fig. 17	Fig. 18	Fig. 19
Specific gravity, 60 F./60 F.	1.013	0.959 to 0.966	0.963 to 0.964	0.994	1.091 to 1.102
Viscosity, Saybolt Furol, 140 F.	823	423 to 543	452 to 507	910	276 to 287
Loss on heating, 163 C., 50 g., 5 hr., per cent	1.14	1.82 to 3.00	1.94 to 3.98	1.31	2.24 to 2.26
Flash point, (Cleveland cup)	430 F.	340 to 360 F.	320 to 355 F.	390 F.	330 to 335 F.
Percentage of residue, 100 penetration	82.0	78.5 to 79.6	78.0 to 81.2	75.2	79.6 to 80.0
Ductility of residue, 77 F. (5 cm. per min.), cm.	110+	110+	110+	110+	110+
Bitumen soluble in CCl_4, per cent	99.67	99.7 to 99.8	99.68 to 99.81	99.90	99.56 to 99.63
Time of reduction, min.	510	340 to 580	300 to 330	165	25

were found throughout the State wherever asphalts of the same type and source were used.

Results of the type that may be expected with asphalts in the first group, the ones producing "mushy" mixes, are shown in Figs. 6 to 15. The mat shown has an average thickness of 1.75 in. In building it, fresh aggregate in sufficient quantity was placed over a well-compacted traffic-bound base which except for two locations did not show base failure due to freezing and thawing. The mixing was done on the road surface using an average of 4.0 per cent bitumen, which is representative of the proportion of bitumen used in this type of mats with the kind of aggregate that was used. Construction of the mat was done by men well experienced in the kind of work performed.

In another location, a carefully constructed mat using clean, well-graded aggregate gave the results shown in Fig. 16. In order to make more positive the evidence furnished by this mat and because it has been stated that the condition shown is typical of a mat which is deficient in fines, the accusation was made that the gradation control had been faulty in that the required proportion of fines had not been produced. In the investigation that ensued it was found that the aggregate was well proportioned, and that it was crushed to produce about 4 per cent passing the No. 200 sieve, which amount together with the fines already present on the surface of the base resulted in a mixture containing an average of 10 per cent passing the No. 200 sieve. The condition shown developed within two weeks after completion of the job in spite of the engineer's efforts to do a good job.

The mat illustrated in Fig. 17 was built in an entirely different manner than the mat shown in Fig. 16. It was built by scarifying the worn out mat in place, breaking it as much as possible, then adding bitumen, remixing, and relaying. Without the evidence furnished by the mats previously illustrated, it would be difficult to understand the reason for the condition shown by this mat.

The mat shown in Fig. 18 is typical of the successful mats: it was 28 months old when the picture was taken. It was built with somewhat more care than the mat shown in Fig. 17 but without the care used in building the mat shown in Fig. 16. The mat had not yet reached a brittle stage as is shown by the tractor marks.

Figure 19 illustrates a mat containing asphalts of the third group: it was 9 months old when the photograph was taken. As the picture shows, a noticeable amount of uncoated aggregate was present; this uncovering did not appear to be due to the washing away of the bitumen but rather to abrasion as most of it was toward the center of the road where traffic travelled the most. The mat was quite brittle as Fig. 20 shows. Progressive hardening from the top to the bottom of the mat and from the shoulders inward was noticeable. When great care is not used in making mats with this type of asphalt, a "greasy" mat will result if an excess of fines is present, while if too much coarse material is present the mat may develop into a loose mixture which will dust under traffic.

Table 1 shows the common specification characteristics of the asphalts used in the aforementioned mats.

Samples of the asphalts used in the aforementioned mats gave, when mixed with the laboratory standard sand, mixes of the first group with asphalts used in the mats shown in Figs. 7, 16, and 17; mixes of the second group with the asphalt used in the mat shown in Fig. 18, and mixes of the third group with the asphalt used in the mat shown in Fig. 19.

A direct comparison of the aforementioned results is open to question in view of the differences in viscosity. Using asphalts from the same source and type but with viscosity of the same range, new mixes were made which were found to group themselves in the same order as the mixes made using the same asphalt that was used in making the mats. The first trial was made using asphalts of the characteristics shown in Table II.

TABLE II.—CHARACTERISTICS OF ASPHALTS USED IN FIRST TRIAL MIXES.

Tests	Asphalt 1 (Fig. 7)	Asphalt 2 (Fig. 16)	Asphalt 3 (Fig. 17)	Asphalt 4 (Fig. 18)
Specific gravity, 60 F/60 F.	1.013	0.971	0.970	0.994
Viscosity, Saybolt Furol, 140 F.	823	876	850	910
Loss on heating, 163 C., 50 g., 5 hr., per cent	1.14	1.90	1.24	1.31
Flash point (Cleveland cup)	430 F.	380 F.	360 F.	390 F.
Percentage of residue, 100 penetration	82.0	82.9	81.9	75.2
Ductility of residue, 77 F. (5 cm. per min.), cm.	110+	110+	110+	110+
Bitumen soluble in CCl_4, per cent	99.67	99.76	99.62	99.9
Time of reduction, min.	510	365	315	165

TABLE III.—CHARACTERISTICS OF ASPHALTS USED IN THE SECOND TRIAL.

Tests	Asphalt 1 (Fig. 7)	Asphalt 2 (Fig. 16)	Asphalt 3 (Fig. 17)	Asphalt 4 (Fig. 18)	Asphalt 5 (Fig. 19)
Specific gravity, 60 F./60 F.	0.996	0.963	0.964	0.990	1.087
Viscosity, Saybolt Furol, 140 F.	457	449	452	560	483
Loss on heating, 163 C., 50 g., 5 hr., per cent	2.14	1.82	1.94	1.95	3.02
Flash point, (Cleveland cup)	375 F.	360 F.	355 F.	390 F.	330 F.
Percentage of residue, 100 penetration	77.9	78.9	78.0	71.0	81.6
Ductility of residue, 77 F. (5 cm. per min.), cm.	110+	110+	110+	110+	110+
Bitumen soluble in CCl_4, per cent	99.50	99.74	99.81	99.99	99.55
Time of reduction, min.	560	580	330	180	35

A second trial was made using asphalts of a lower grade in viscosity. These asphalts had the characteristics shown in Table III.

The mixes in the second trial gave results which duplicated the results obtained in the first trial.

Attempts were made to correlate the results just described with physical and chemical characteristics of the asphalts. No correlations were found with such characteristics as low-temperature ductility, fluidity factor, or spot test. A correlation seemed to be indicated with chemical composition. Asphalts in the first group showed low asphaltene contents (roughly less than 6 per cent), the asphalts in the third group showed, on the average, high asphaltene contents (above 12 per cent), while the asphalts in the second group showed asphaltene contents ranging from 6 to as high as 20 per cent. Correlations with other chemical characteristics were not consistent probably because the techniques for making the chemical tests are not sufficiently well worked out to give uniform results.

In studying and observing the behavior of mats in the field, it was noticed that mats which showed "bleeding" of the type illustrated in Fig. 12 also showed stripping of the bitumen from the aggregate; this condition was typical of mats made with asphalts giving mixes of the first group. In the field, resistance to stripping was evaluated by inspection: a stripped mixture was easily determined by making a hole in the mat and examining the condition of the aggregate in the cross-section. A stripped mix showed, at the base of the mat, aggregate which was slightly stained or completely uncovered while close to the surface of the mat the mixture showed a characteristic enrichment. Mixes which stripped readily showed, in the interior of the mat, a characteristic greasy appearance. Mixtures which were not stripped showed uniformity in color from the top to the bottom of their thickness.

Resistance to stripping was found to increase with increases in asphaltene content, but it was not possible to determine to what extent such increases are affected by the kind of aggregate used. It was found, however, that weather conditions at the time of construction and density of the mixtures influence decidedly the amount of stripping. For example, a mixture containing asphalts of the first group can be kept from "bleeding" and stripping by laying the mat in warm, dry weather using a gradation of aggregate of the dense-graded type. The climate in Wisconsin, however, does not always make possible the laying of dry mixes.

A positive correlation was obtained between the characteristics of the mixes and the consistency of the residues of the asphalts obtained with A.S.T.M. Method D 243 – 28 T. Using a heating period of 165 min., which has been indicated to be the period of reduction of an asphalt which has given satisfactory service performance, asphalts which gave mixes of the type contained in the first group showed consistencies softer than that of 175 sec. float at 50 C. Asphalts giving mixes of the second group had consistencies ranging from 300 sec. float at 50 C. to penetration of 10 at 77 F., while asphalts giving mixes in the third group showed penetrations harder than 10 at 77 F.

Repeated trials using asphalts furnished in Wisconsin for the past several years confirm the aforementioned findings.

Conclusions

Field and laboratory evidence indicate that a heat test of the type described in A.S.T.M. Method D 243 – 28 T can be used for the evaluation of performance in service of slow-curing asphalts.

The test can be used for control purposes by either specifying the time required to reduce the consistency of the asphalt from original to a consistency of either 100 or 150 penetration, or by specifying the consistency of the residue obtained after heating the asphalt for a given period of time.

The time of reduction or the heating period required to obtain a residue of given consistency can be determined for an asphalt or asphalts which have given satisfactory performance in service and this time, or times, may then be used as a specification requirement. A consideration of construction practices followed in using the asphalts is of great value in establishing the requirement.

Acknowledgment:

The author thanks A. T. Bleck, Construction Engineer for the State Highway Commission of Wisconsin, for counsel and comments which helped materially in planning and keeping the balance between laboratory and field work. Grateful acknowledgment is made for the assistance rendered by several of the author's associates in the laboratory of the State Highway Commission, particularly for that of R. R. Marquardt and E. M. Sommers.

DISCUSSION

Mr. V. A. Endersby.[1]—I notice that in Fig. 11 there appears to have been an increase in asphaltenes for the first four months, without a decrease in oil constituents. Then the decrease in oil constituents begins, and that shows up more in the top 1/4 in. of the mat.

An increase in asphaltenes is generally largely the result of the action of ultraviolet light but also the result of polymerization.

I am wondering whether Mr. Zapata has anything to offer on this phenomenon that shows here an increase in asphaltenes, which seems to precede the evaporation for the first four months; and what the corresponding effects of that would be; or is the accuracy of the work such that it could be accidental? It does not seem as though it could, because it seems to have the same trend both in the top part of the mat and the lower part.

Mr. Joseph Zapata.[2]—If the ratio of resins to asphaltenes is calculated, it is found that it remains constant and that actually the reduction is in the oily constituents. For that reason we felt justified in assuming that evaporation was taking place. We deduced that if a change like condensation or oxidation took place, the proportions among the three constituents would vary sometime, but since the ratio of the resins to the asphaltenes remained

[1] Asphalt Dept., Shell Oil Development Co., Emeryville, Calif.

[2] Chief Chemist and Assistant Materials Engineer, Bituminous Laboratory, State Highway Commission of Wisconsin, Madison, Wis.

constant, it appeared to us that evaporation was the dominant change.

In the light of other investigations, especially those of Thurston, oxidation probably enters in the reduction to consistency of 100 penetration. However, our data show that the evaporation effects are predominant and on this basis the conclusion that this is the dominant change can be safely assumed.

MR. ENDERSBY.—Mr. Zapata speaks of the scattered results found in the triaxial test, which do not appear in the compression test. A compression test is a special case of a triaxial test and I am unable to understand why there should be more scattered results because the ratio of dimensions to particle sizes, and the method of compaction, which usually affect reproducibility, are the same in both cases. I am wondering whether he has anything to offer on that.

MR. ZAPATA.—The physical testing of bituminous mixes was one of the most difficult problems that we encountered. In order to get comparable results—meaning variations within a range of plus or minus 10 per cent from an average—it was necessary to use extreme care in sizing and proportioning the aggregates, specially those containing large particle sizes, and to follow in detail a minutely prescribed technique in preparing the specimens for test. The same care was found to be needed regardless of the test procedure used.

In the case of the compression test we had the least scattering of individual values and for that reason the test was selected to make the comparison that we have reported.

We have adopted the practice of making a number of tests, analyzing the data statistically, and accepting the results if the analysis justifies it. A practice of this nature does much toward making clear the effect of the various variables.

I understand that Mr. Endersby has had very good results with the triaxial test. I imagine, therefore, that that is why he questions our not including it.

MR. ENDERSBY.—I would change that last statement of Mr. Zapata's and say that we have had the same results with the compression test as we have had with the triaxial and reproducibility has not been too good.

As Mr. Zapata has said, the obtaining of reproducibility in these mixtures is quite difficult and evaluation is a statistical matter. But the question I had in mind was whether there was any reason why a triaxial test should be inherently less reproducible than the compression test. There appears to be some factor not yet determined in Mr. Zapata's work on that.

There is one other point I want to mention. Mr. Zapata brings out the fact that you cannot get a good test of a bituminous mixture by compression alone and that it requires some measurement of cohesion. That is in line with general experience.

I might show the three methods that you use that way: the triaxial test, Mr. Zapata's, and Mr. Hveem's. In the triaxial test, you have the compression test and the c value of cohesion. Mr. Zapata's is the compression test and the impact. Mr. Hveem's is the stabilometer and the cohesiometer.

So general experience seems to show the absolute necessity of using two different types of tests, but the triaxial test has certain advantages when used with the Mohr diagram. Thereby the tensile strength can be derived from compressive strength taken at different values of lateral pressure.

MR. ZAPATA (*author's closure, by letter*).—It is not unusual to find that a test is singled out, either knowingly or mistakenly, as the important and, perhaps, sole measure of whatever characteristics are believed to be desirable or needed in a bituminous material. The author, therefore, feels justified in explaining, with emphasis, that his report is not intended to build up as a "cure-all" the test procedure discussed therein. There will be no justification in assuming that asphalts with all the optimum characteristics will be obtained by simply specifying time of reduction or consistency of residue. The test is really a measure of "setting" characteristics; field experience and observation have shown that these characteristics are quite important.

Experience indicates that a range of times of reduction or consistencies of residue may be selected and that such selection will assist in obtaining materials which have a number of the desirable characteristics; however, the selection of materials with specific characteristics will require the use of properly selected tests. It seems pertinent at this time to invite those concerned with the preparation of specifications for slow-curing asphalts to consider changing the current type of specifications to a new type or form containing requirements for consistency, for rate of set, for resistance to stripping, and for resistance to the effects of weathering. With the exception of requirements for consistency, requirements for the other characteristics named are lacking in current specifications although experience in the field indicates their need.

Philadelphia Covers Synthetic Bristles and Acrylic Esters

AT THE MEETING on September 23 sponsored by the Philadelphia District Committee, some 175 A.S.T.M. members, guests and visitors heard two interesting discussions by members of the staff of the Eastern Regional Research Laboratories at Wyndmoor (Chestnut Hill), of the U. S. Department of Agriculture. Dr. T. L. McMeekin described his work to discover potential materials which could be formed satisfactorily into synthetic bristles. The protein casein, plasticized with water and subsequent stretching and treatment in quinone and formaldehyde, has given some very interesting results. It is hoped to include in the December BULLETIN a detailed outline of this talk and also the one on Acrylic Esters given by Dr. C. H. Fisher which was of much interest, particularly to the chemists and chemical engineers present. In addition to a background of the development of these materials, a large number of possibilities were explored, and the speaker covered some of their practical applications and results.

This meeting, the first of the 1943–1944 series by the Philadelphia District Committee, was very successful. Chairman F. G. Tatnall presided, with Messrs. R. W. Orr, E. J. Albert, A. O. Schaefer, and Judson Vogdes cooperating.

Program of Activities of Committee D-19 on Water for Industrial Uses, by Max Hecht

ENGINEERS are increasingly becoming "water conscious," particularly where they direct activities using water for processing of goods, and in evaporative industries where the product is used for power and heat. A.S.T.M. Committee D-19 on Water for Industrial Uses, completing its first ten years of service to industry and recognizing the technologic interest in industrial water, is making significant changes in its program of activities. During the year it has expanded the scopes of its subcommittees, and has organized a new subcommittee on methods of testing.

A new outline of the functional activities of the standing committee is shown in the accompanying outline.

Pertinent extracts from reports of the subcommittees follow:

Editorial.—(E. P. Partridge, Hall Laboratories, Inc., Chairman)

A preliminary statement for a Manual on Industrial Waters was sent to the members, with many specific suggestions resulting. Whether the proposed manual should comprise essentially methods of sampling, analysis and testing, reporting of analysis, with only a brief introduction, or whether it should be expanded to include a more detailed discussion of certain subjects such as Composition of Water Supplies, Industrial Uses of Water, Difficulties Caused by Water, and Methods of Correcting These Difficulties, must be decided.

There is general agreement that the subcommittee should undertake the preparation of definitions of terms used in connection with industrial water, such as deposit, scale, slime, corrosion, pitting, tuberculation, etc.

Methods of Sampling.—(D. K. French, Dudley K. French and Associates, Chairman)

The activities will cover two main topics, water and resultant deposits. The existing standard on Methods of Sampling, (D 510 – 41), discusses the general principles for sampling water. It is the subcommittee's purpose to supplement or modify them so that their application to boiler waters and boiler operation would be better defined and be more valuable. Procedures are to be developed for boiler and confined waters at super atmospheric pressures and for the resultant deposits.

Methods of Analysis.—(H. C. Miller, Public Service Elec. & Gas Co., Chairman)

This work falls into three categories: A, Analytical; B, Electrometric; and C, Special Methods.

Section A.—Revisions will be drafted in the standard method of Determining of Hydroxide Ion in Industrial Water, (D 514 – 41). It is hoped to issue without delay at least one method for the Determination of Dissolved Oxygen and to publish for information several other proposed methods.

Section B.—This section will develop methods for determining electrical conductivity of industrial waters, and in cooperation with Committee E-1, methods for the determination of pH in industrial waters.

Section C.—Foremost in this work is a review of the literature to determine acceptable application of such instruments as the polarizing microscope, the spectrograph, and X-ray diffraction for the examination of scales and deposits, and consideration of such problems as scope, limitations, and preparation of the sample which are common to the instruments.

Classification.—(W. C. Schroeder, U. S. Bureau of Mines, Chairman)

This work is intended to provide a system of classification which will make it possible to judge the action of an unknown water in any given process from its analysis. The committee is well aware of the difficulties and agreed that no mathematical formula or graphs would set up sharp or arbitrary lines of demarkation.

It is believed, however, that a limited group of waters can be chosen and their use in a number of industrial applications accurately described. These waters would be representative of the great majority used in industrial processes. Then by comparing the analysis of an unknown water with these samples it should be possible to form some idea of its action in a given instance.

Samples are now being selected to form the basis for classification. The next step will be a description of the use of these waters in various industrial applications.

Methods of Testing.—(V. V. Kendall, National Tube Co., Chairman)

A group on "caustic" embrittlement is to draft a standard method of testing boiler steel for "caustic" embrittlement using the detector developed by the U. S. Bureau of Mines. The preparation of a summary of the literature on methods of testing that have been or are being employed in the study of water with respect to corrosivity from the viewpoint of the media and not the resistance to corrosion of specific metals or alloys has been arranged for. After this has been circulated to the members for their critical scrutiny and comments, a program of work will be organized.

Mention should be made of the efforts of Committee D-19 to introduce among engineering students a knowledge of the standard methods of reporting results of analysis of water intended for industrial use. A communication with a copy of the applicable A.S.T.M. standard, D 596, was sent to some 175 heads of chemical engineering and chemistry departments and accredited schools.

ORGANIZATION OF A.S.T.M. COMMITTEE D-19 ON WATER.

1. Advisory
2. Editorial
3. Methods of Sampling
   - A. Water
     - (1) Solid
     - (2) Fluid
     - (3) Vapor
   - B. Resultant Deposits
     - (1) Scales
     - (2) Corrosion Products
     - (3) Organic Growths
4. Methods of Analysis
   - A. Standard Methods
     - (1) Analytical
       - (a) Macrochemical
       - (b) Microchemical
       - (c) Colorimetric
     - (2) Electrometric
       - (a) Conductimetric
       - (b) Potentiometric
       - (c) Dropping Mercury Electrode
     - (3) Special by
       - (a) Polarizing Microscope
       - (b) Biological Microscope
       - (c) Metallurgical Microscope
       - (d) X-Ray
       - (e) Spectroscope
   - B. Field Tests
5. Classification
6. Methods of Testing
   - A. Corrosivity
     - (1) General Corrosion
     - (2) Corrosion Fatigue
     - (3) Embrittlement
   - B. Stability

New A.S.H.V.E. Research Director

ANNOUNCEMENT has been received of the appointment of Cyril Tasker as Director of Research of the American Society of Heating and Ventilating Engineers. A graduate of the University of Manchester, he was for a number of years affiliated with the British Fuel Research Board and then for thirteen years was a member of the Ontario Research Foundation technical staff. His offices will be at the A.S.H.V.E. headquarters, 51 Madison Ave., New York, N. Y.

The Chemist and Insulation Research

RECENTLY received from the Committee on Chemistry of the National Research Council's Conference on Electrical Insulation is a 72-page review of the contributions of chemists to insulation research, covering the calender year 1942. Leading technologists have reviewed various fields in many of which A.S.T.M. has been active. Topics covered include the following:

Review of the Field of Anomalous Electrical Dispersion
Review of Progress in Rubber Insulation
Insulating Paper
Synthetic-Plastic Electrical Insulation
Chemical Progress in Insulating Oils
Ceramic and Glass Insulation

Valuable parts of the review are the extensive bibliographies. It is indicated that copies of this publication can be obtained from the committee's chairman, G. T. Kohman, Bell Telephone Laboratories, Murray Hill, N. J.

Effects of Minor Alloying Elements on Aluminum Casting Alloys

Part II—Aluminum-Silicon Alloys

By W. Bonsack[1]

EDITOR'S NOTE.—This paper covering aluminum-silicon alloys is a continuation of the study presented in the paper by the author on "The Effect of Minor Alloying Elements on Aluminum Casting Alloys" published in ASTM BULLETIN, No. 117, August, 1942, p. 45 for which paper Mr. Bonsack was awarded the Dudley Medal at our 1943 Annual Meeting.

As mentioned in connection with Part I of this study, this outstanding technical contribution based on exhaustive work by the National Smelting Co. should be of interest to every technologist concerned with die casting and foundry problems in the fields covered.

HISTORICALLY, aluminum-silicon alloys are not so old as aluminum-copper alloys. They were introduced in America as well as in Europe around the early 1920's. After a slow start they became more popular, especially in Europe. The early alloys were the 13 per cent and 5 per cent aluminum-silicon alloys which were used in the sand-, chill-, and die-cast state. In the United States the 5 per cent silicon alloy was largely used for sand and permanent-mold casting, while the 13 per cent silicon alloy found its greatest use in die casting. The high fluidity and the freedom from hot shortness made this alloy a favorite with the die casters, while for the sand and permanent-mold foundries it was too new, too different to handle due to its peculiar solidification characteristics. It requires larger risers to take care of the solidification shrinkage or piping, and to get the maximum properties it requires the now well-known modification processes such as adding metallic sodium or fluxing with sodium fluoride before pouring (*9*, *69*).[2] The 5 per cent silicon alloy does not necessarily, because of its basic ductility, require these special treatments and is, therefore, easier to handle in the sand and permanent-mold foundry.

Aluminum-copper alloys had been used for years, and there was really no great incentive to use the 13 per cent silicon alloys, except in special cases in the permanent-mold and sand casting field. This situation was and is quite different in Europe. We have the greatest copper supply in the world—Europe has relatively little, most copper is imported and, therefore, not always readily available. (This is probably one of the reasons why aluminum-zinc alloys were and still are more widely used in Europe than aluminum-copper alloys.) Silicon, therefore, is a very welcome substitute for copper in casting alloys. This, likely, is one of the foremost reasons why European countries have fostered aluminum-silicon alloys earlier and to a much greater extent than the United States. Furthermore, aluminum-silicon alloys can be produced directly from lower grade ores by electrothermic processes which have been used to a great extent in France, Switzerland, and Germany. This meant a greater independence from high-grade bauxite.

The above-mentioned reasons for the greater use of silicon alloys in Europe are purely economic, but silicon alloys have other virtues which make them desirable from the engineering point of view. Aluminum-silicon alloys have lower specific gravity than most other aluminum alloys, even lighter than aluminum itself. The fluidity or mold-filling characteristic is greater than that of most other aluminum alloys (*159*, *171*). The thermal expansion is lower than in most other aluminum alloys. The hardening effect of silicon is lower than that of copper, or magnesium. While 8 per cent copper-aluminum alloy, sand cast, will give a tensile strength of 24,000 psi. and an elongation of 2 per cent, the 13 per cent silicon alloy will give the same, and by modification will give even better properties. Eight per cent copper alloys is hot short, 13 per cent silicon is not. The specific gravity of the two alloys is 2.80 against 2.65, respectively. The disadvantages are the greater shrinkage (piping), previously mentioned, and poorer machinability. The latter disadvantage can be overcome, however, as will be shown later.

These two alloys, the 5 per cent and 13 per cent silicon, have desirable properties, and it is only natural that as time passed, other alloys were developed from these basic binary aluminum-silicon alloys. There are numerous reports in the technical literature of investigations of the effect of different elements on aluminum-silicon alloys, and the patent literature of the world is voluminous on aluminum-silicon alloys in combination with other elements. The American Society for Testing Materials specifications discussed here include eight alloys of the aluminum-silicon type (see the accompanying sections of Tables I and II repeated from Part I of this paper). In group 5 are the specifications for the sand-, chill-, and die-cast 5 per cent silicon alloys. Group 6 includes the 13 per cent silicon alloy specifications for the same methods of casting. These two groups represent the simple binary aluminum-silicon alloys. The effect of the minor alloying elements with probably one exception (iron) is most similar in both types of alloys as will be seen in the following.

GROUP 5: 5 PER CENT SILICON ALLOY

The popularity of 5 per cent silicon alloy is mainly due to the ease with which it fills the molds. The castings obtained from this alloy are usually freer of porosity and, consequently, more leak proof than those made from copper alloy. The silicon having nearly the same electrolytic potential as aluminum does not cause as much corrosion as the equivalent amount of copper in aluminum-

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] Director of Laboratories, The National Smelting Co., Cleveland, Ohio.

[2] The italic numbers in parentheses refer to the reports and papers appearing in the list of references appended to Part I of this paper ASTM BULLETIN, No. 117, August, 1942, p. 54.

TABLE I.—CHEMICAL ANALYSIS OF A.S.T.M.-ALUMINUM-SILICON ALLOYS.

Group	A.S.T.M. Specifications	Alloy	Cast[a]	Chemical Analysis, per cent											
				Copper	Iron	Silicon	Magnesium	Manganese	Zinc	Nickel	Tin	Chromium	Titanium	Others	Aluminum
5	B 26 – 41 T	J	S	0.4	0.8	5.0 + 1.0 − 0.5	0.05	0.3	0.2	....	...	....	0.2	0.3	remainder
	B 26 – 41 T	JJ	S	0.1	0.8	5.0 + 1.0 − 0.5	0.05	0.05	0.05	....	...	....	0.2	0.05 each	remainder
	B 108 – 41 T	9	P	0.4	0.8	5.0 + 1.0 − 0.5	0.05	0.3	0.3	....	...	....	....	0.3	remainder
	B 108 – 41 T	9A	P	0.1	0.8	5.0 + 1.0 − 0.5	0.05	0.05	0.05	....	...	....	....	0.05 each	remainder
	B 85 – 39 T	IV	D	0.6	2.0	4.5 to 6.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	95.00
6	B 26 – 41 T	K	S	0.15	0.8	12.5 ± 0.5	0.05	0.2	0.1	....	...	....	....	0.2	remainder
	B 108 – 41 T	8	P	0.3	0.8	11.0 ± 1.0	0.05	0.5	0.3	....	...	....	....	0.5	remainder
	B 85 – 39 T	V	D	0.6	2.0	11.0 to 13.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	88.00
7	B 26 – 41 T	N	S	1.25 ± 0.25	0.5	5.0 ± 0	0.5 ± 0.1	0.1	0.05	....	...	....	0.2	0.2	remainder
	B 85 – 39 T	VI	D	1.5 to 2.5	2.5	2.5 to 3.5	0.1	0.3	0.8	0.5	0.1	....	....	0.2	95.00
	B 85 – 39 T	XI	D	1.0 to 3.0	2.0	7.0 to 9.0	0.1	0.3	0.5	0.5	0.1	....	....	0.2	90.00
	B 26 – 41 T	M	S	0.2	0.5	7.0 ± 0.5	0.3 ± 0.1	....	0.05	....	...	....	0.2	0.05 each	remainder
	B 108 – 41 T	10	P	0.2	0.5	7.0 ± 0.5	0.3 ± 0.1	0.05	0.05	....	...	....	....	0.05 each	remainder
	B 108 – 41 T	6	P	1.0 ± 0.5	1.3	12.0 ± 1.0	1.0 ± 0.25	0.05	0.1	2.5 ± 0.5	...	....	....	0.2	remainder
	B 108 – 41 T	7	P	1.5 ± 0.5	0.9	12.25 ± 0.75	0.55 ± 0.15	0.75 ± 0.15	0.4 0.05	0.05	...	....	....	0.3	remainder
8	B 26 – 41 T	L	S	0.1	0.4	0.25	3.75 ± 0.5	0.6	....	....	...	....	0.2	0.05 each	remainder
	B 26 – 41 T	O	S	0.2	1.0	0.6	0.5 ± 0.1	....	5.0 + 0.7 − 0.2	....	...	0.5 ± 0.1	0.2 ± 0.1	0.05 each	remainder

[a] S = sand cast; P = permanent mold; D = die cast.

TABLE II.—PHYSICAL PROPERTIES OF A.S.T.M.-ALUMINUM-SILICON ALLOYS.

Group	A.S.T.M. Specifications	Alloy	Cast	As Cast				Heat Treatment No. 1		Heat Treatment No. 2		Heat Treatment No. 3		Charpy Impact, ft-lb.
				Tensile Strength, psi.		Elongation in 2 in., per cent		Tensile Strength	Elongation	Tensile Strength	Elongation	Tensile Strength	Elongation	
				Minimum	Typical	Minimum	Typical	Minimum	Minimum	Minimum	Minimum	Minimum	Minimum	
5	B 26 – 41 T	J	S	17 000	....	3.0	...	....	...	....	...	....	...	...
	B 26 – 41 T	JJ	S	17 000	....	3.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	9	P	21 000	....	2.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	9A	P	21 000	....	2.5	...	....	...	....	...	....	...	...
	B 85 – 39 T	IV	D	....	29 000	...	3.5	....	...	....	...	....	...	4.5
6	B 26 – 41 T	K	S	24 000	....	5.0	...	....	...	....	...	....	...	...
	B 108 – 41 T	8	P	27 000	....	3.0	...	....	...	....	...	....	...	...
	B 85 – 39 T	V	D	....	33 000	...	1.5	....	...	....	...	....	...	2.0
7	B 26 – 41 T	N	S	....	....	...	...	....	...	32 000	2.0	25 000	1.0	...
	B 85 – 39 T	VI	D	....	30 000	...	3.5	....	...	....	...	....	...	5.0
	B 85 – 39 T	XI	D	....	32 000	...	1.7	....	...	....	...	....	...	3.0
	B 26 – 41 T	M	S	....	....	...	...	26 000	5.0	30 000	3.0	....	...	...
	B 108 – 41 T	10	P	....	....	...	...	28 000	5.0	30 000	3.0	....	...	...
	B 108 – 41 T	6	P	....	....	...	...	28 000	...	36 000	...	....	...	...
	B 108 – 41 T	7	P	....	....	...	...	32 000	...	36 000	...	....	...	...
8	B 26 – 41 T	L	S	22 000	....	6.0	...	....	...	....	...	....	...	...
	B 26 – 41 T	O	S	30 000 (aged)	....	3.0 (aged)	...	....	...	....	...	....	...	...

TABLE XI.

	Alloy No. 1	Alloy No. 2	Alloy No. 3	Alloy No. 4	Alloy No. 5
Copper, per cent	0.58	0.34	0.68	0.24	0.61
Silicon, per cent	4.16	5.07	5.27	5.11	4.41
Nickel, per cent	0.01	Nil	Nil	0.22	Nil
Iron, per cent	1.85	1.48	1.29	1.89	2.53
Manganese, per cent	0.01	0.07	0.02	0.04	0.05
Magnesium, per cent	0.07	0.06	0.01	0.01	0.02
Zinc, per cent	0.02	0.44	Nil	0.11	5.90
As Cast					
Tensile strength, psi. (1/4 in. diameter round bars)	30 160	25 680	29 600	29 610	30 150
Elongation in 2 in., per cent	4.6	2.3	3.6	3.7	2.1
Exposed for 5 Yr. at Key West, Fla.					
Tensile strength, psi.	31 500	27 000	31 000	29 700	31 000
Elongation in 2 in., per cent	4.4	3.1	4.5	3.7	2.0

copper alloys. Although the tensile strength when cast in sand is relatively low (around 18,000 to 20,000 psi.) its ductility is better than that of any other common casting alloy. By the addition of a modifier such as sodium, even greater ductility can be obtained. It is not uncommon to find such properties as 20,000 to 23,000 psi. tensile strength and 10 to 16 per cent elongation in a good permanent mold casting or 18,000 to 20,000 psi. tensile strength and 5 to 10 per cent elongation in sand castings. However, the yield strength is low, which fact excludes this alloy from structural, highly stressed castings. Castings from this alloy have been used for cast cooking ware, chemical apparatus, architectural castings, marine castings, searchlight housings, and other applications subject to corrosive media. Large tonnages are used for automotive casting where freedom from porosity and leakage is important.

The specifications B 26 – 41 T,[3] alloys J and JJ, are drawn for sand castings; B 108–41 T,[4] alloys 9 and 9A, for permanent mold castings; and B 85–39 T,[5] alloy IV, for die castings. In all of them the silicon content is 4.5 to 6.0 per cent, and the iron 0.8 per cent maximum with the exception of the die casting alloy IV which allows 2.0 per cent maximum.

Iron is limited to these amounts, because it forms large needles and plates of an iron-aluminum-silicon complex which rapidly reduces the alloy's ductility. The effect of high iron is more pronounced in sand castings than in either permanent-mold or die castings. The quick freezing in these chill molds prevents the formation of the large size needles or plates of aluminum-iron-silicon complex found in sand castings, and it is known that the reduction of elongation in a permanent mold casting caused by 1 per cent iron in the alloy is less than by 0.8 per cent iron in the sand casting. Therefore, it is possible to use 5 per cent silicon alloys with an iron content of 1 per cent in permanent mold castings and still have more than 3 per cent elongation. In die castings, 2 per cent iron is not uncommon and still 29,000 psi. tensile strength and 3.5 per cent elongation are given as typical properties.

Table XI[6] shows the iron content of the die-casting alloy apparently common around 1930. The five different analyses represent castings made by five different die casters. The alloy marked No. 1 contains 1.85 per cent iron and has 4.6 per cent elongation. Alloy No. 4 has also 1.89 per cent iron and an elongation of 3.7 per cent. The higher elongation in the alloy No. 1 is probably due to the lower silicon content. Alloy No. 2 shows properties lower than any of the others and lower than specified. The reason for this probably lies in the casting itself rather than in the alloy since most of the other alloys cast by this particular die caster are considerably lower in properties than the others.

The effect of iron on the corrosion resistance of the alloy seems negligible as shown by the second set of properties given in the table. After 5 yr. exposure to a salt-water atmosphere no detrimental change occurred in spite of the large variation in the iron contents of the alloys. Even after 10 yr. exposure, visual examination did not reveal enough corrosion to warrant testing the exposed specimen.

Copper is limited to 0.1 per cent in alloys JJ and 9A; to 0.4 per cent in alloys J and 9; and to 0.6 per cent in alloy IV. The reason for the low limits of copper in alloys JJ and 9A is said to be the higher corrosion resistance desired in these alloys. Copper is said to reduce the resistance considerably. Copper as compared to aluminum has a more positive electrolytic potential, and, therefore, when combined with aluminum it forms an electrolytic cell which causes destruction of the aluminum when immersed into an electrolyte. In these low limits the copper is largely in solid solution and most likely not active as theoretically supposed. The above table and other data referred to later bear this statement out. Advantages gained by small copper contents in this alloy are improved machinability (since copper hardens the soft aluminum crystals), improvement of resistance to vibration (fatigue), and increase in tensile strength and yield point without marked reduction in ductility. It should be pointed out that in the above table the copper content of the alloys varied roughly from 0.2 to 0.7 per cent without noticeable changes in the tested properties.

Magnesium in silicon alloys acts as a powerful hardening element. Silicon with which it combines preferentially is plentiful. Therefore, wherever ductility is required it should be limited to low figures such as 0.05 per cent or

[3] The tentative specification was revised in 1942 and is now published as Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 42 T) in the 1942 Book of A.S.T.M. Standards, Part I, p. 1120. At the 1943 Annual Meeting of the Society the specification was further revised as B 26 – 43 and will appear in the 1943 Supplement to the Book of A.S.T.M. Standards.

[4] Tentative Specifications for Aluminum-Base Alloy Permanent Mold Castings (B 108 – 41 T) 1942 Book of A.S.T.M. Standards, Part I, p. 1128.

[5] This tentative specification has been adopted as a standard of the Society and is now published as Standard Specifications for Aluminum-Base Alloy Die Castings (B 85 – 42) 1942 Book of A.S.T.M. Standards, Part I, p. 824.

[6] Taken from Report of Subcommittee V on Exposure and Corrosion Tests of the Society's Committee B-6 on Die-Cast Metals and Alloys, *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 198 (1935).

0.1 per cent. Its influence on the properties of the alloy is the same as shown in the copper alloys. It increases strength, elastic properties, and hardness and also reduces ductility (*56*, *48*). Corrodibility is not adversely affected by magnesium. Machining properties are improved and castability is not changed by its presence (*1*).

Manganese.—In the two "high pure" alloys, the manganese is limited to 0.05 per cent and in the other three alloys to 0.3 per cent. Manganese acts in the same fashion in silicon alloys as discussed in copper alloys. It is especially beneficial in silicon alloys, however, because of its influence on the aluminum-iron-silicon crystal. It changes the needle or platelike crystals into smaller, relatively harmless, forms as shown later in the discussion of 13 per cent silicon. It improves tensile strength, yield strength, and proportional limit without reducing elongation markedly. It is said to improve the die-casting alloy by reducing the sticking of the alloy to the walls of the die. It also improves corrosion resistance. It improves the high-temperature properties of the alloy. But with all these known beneficial effects, the manganese content in these alloys is kept relatively low in the specifications. The benefit of manganese in silicon alloys will be discussed at greater length under the complex silicon alloys.

Nickel in aluminum-silicon alloy does not form any other compounds than the one found in pure aluminum, that is, it is present in the form of Al_3Ni crystals. The solid solubility of this compound is small, on the order of 0.25 per cent maximum at eutectic temperature and decreasing to about 0.1 or less at 300 C. Any amount larger than that will be found in the eutectic. With silicon present, this eutectic approximates a composition of 11.8 per cent silicon, 3.9 per cent nickel, and 84.3 per cent aluminum (*45*, *237*).

The properties derived from the addition of nickel to aluminum-silicon alloys are similar to those mentioned in the discussion of the copper alloys, that is, it increases tensile strength, yield strength, proportional limit, and reduces elongation and impact strength slightly. In the sand-cast and chill-cast alloy specifications, nickel is included in the "other impurities" and, therefore, a small amount such as 0.10 per cent or less is allowable while in the die-casting specification, nickel is allowed to be present up to 0.5 per cent. In Table XI, alloy No. 4 contains 0.22 per cent nickel while the others contain less than 0.01 per cent. Still the properties of alloy No. 4 are as good as those of the alloys without nickel, and no deterioration of properties could be found after 5 yr. exposure. It might be argued that the nickel was in solid solution in this case, but it is very unlikely that the constituents in a casting are in an ideal equilibrium without the application of an extensive heat treatment. Again we must conclude that nickel in small amounts, say in amounts up to 0.5 per cent, will not be different in effect than 0.5 per cent of any other hardening metal such as iron, manganese, or even silicon.

Zinc is kept rather low in these alloys, particularly in the "pure" alloy. The die-casting alloy allows 0.5 per cent while the commercial sand and permanent-mold casting allow only 0.2 and 0.3 per cent, respectively. Zinc is kept to these low limits, because it is said to increase corrodibility. Here again, we refer to Table XI, where we find alloy No. 5 containing 5.90 per cent zinc, alloy No. 2 containing 0.44 per cent zinc, and alloy No. 3 containing no zinc. In none of these can any loss of properties be found which might be attributed to corrosion; and special attention was given to alloy No. 5 with its 5.90 per cent zinc. In all other respects, zinc is also rather innocuous as in most aluminum alloys. Sam Tour[7] stated that up to 1.5 per cent, zinc is not harmful to the mechanical properties of the finished castings. A limitation to 0.05 per cent is unwarranted (*1*). It is said that zinc causes a grain refinement of the aluminum-silicon alloys although not quite so complete as obtained by the use of sodium. An alloy containing 6.5 per cent silicon, 3 per cent copper, and 10 per cent zinc is used in Europe. This alloy is known under the name "Cetal." It is said to have a tensile strength of 25,000 to 32,000 psi. and an elongation of 0.5 to 3 per cent in the cast state (*103*, *172*).

The effect of the elements *tin*, *lead*, *antimony*, *bismuth*, *titanium*, and *chromium* will be discussed later with the 13 per cent silicon alloys. Since the 5 per cent and 13 per cent silicon alloys are very similar and since much more work has been done on the 13 per cent silicon alloy than on the 5 per cent silicon alloy, it simplifies matters considerably to discuss both jointly from here on.

Group 6: 13 Per Cent Silicon Alloy

Specifications B 26, alloy K; B 108, alloy 8; and B 85, alloy V, are written for this alloy in the sand-cast, chill-cast, and die-cast state, respectively.

Iron is probably the most undesirable element in binary aluminum-silicon alloys. As mentioned before, it is present in the form of ternary complex compound. It

[7] Sam Tour "Aluminum Alloys for Pressure Die Castings," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 494 (129).

TABLE XII.

	Alloy No. 1	Alloy No. 2	Alloy No. 3	Alloy No. 4	Alloy No. 5
Copper, per cent	0.64	0.98	0.15	0.05	0.20
Silicon, per cent	13.00	12.96	12.42	12.97	10.72
Nickel, per cent	0.08	0.03	nil	0.02	nil
Iron, per cent	1.59	1.52	1.89	1.35	4.34
Manganese, per cent	0.19	0.09	0.03	0.02	0.06
Magnesium, per cent	0.09	0.12	0.01	0.03	0.04
Zinc, per cent	0.22	0.90	0.03	0.06	0.60
Tin, per cent	....	....	0.06	....	....
Lead, per cent	....	....	0.21	....	....
As Cast					
Tensile strength, psi. (1/4 in. diameter round bars)	34 090	25 810	28 480	34 650	28 120
Elongation in 2 in., per cent	1.4	0.9	1.4	2.8	1.1
Exposed for 5 Yr. at Key West, Fla.					
Tensile strength, psi. (1/4 in. diameter round bars)	34 700	27 400	29 600	36 900	25 800
Elongation in 2 in., per cent	1.0	0.9	1.5	1.7	0.5

forms a ternary eutectic with aluminum and silicon at a composition of 12.5 per cent silicon, 0.5 per cent iron, and 87 per cent aluminum. Any amount over 0.5 per cent iron will be present as an aluminum-iron silicide in large needles which up to about 0.8 per cent iron increase strength and hardness and slightly reduce the ductility; above 0.8 per cent iron, the elongation and also the strength drop rapidly. It is, therefore, advisable to keep the iron content in the binary aluminum-silicon alloy below 0.8 per cent in sand castings (*58*) and below 1 per cent in chill castings. Even in die castings, it appears necessary to keep the iron below 1.5 per cent to insure at least 1 per cent elongation. Therefore, the Society's specifications for sand and permanent-mold castings limit the iron at the proper amount, but for the die castings the limit seems too high. Returning to the test results reported in 1935 by the Society's Subcommittee V, on Exposure and Corrosion Tests[3], Table XII is taken from this report.

Five different variations of alloy V had been tested right after die casting and after 5-yr. exposure in the corrosive atmosphere at Key West, Fla. The silicon content of four of these alloys falls in one range while alloy No. 5 is about 1.5 per cent lower. The iron content of these alloys varies from 1.35 per cent to 4.34 per cent. Alloy No. 4 has the lowest iron content and with it the highest strength and elongation in the as-cast condition as well as after 5-yr. corrosive exposure. During the exposure the tensile strength increased slightly and the elongation dropped considerably, although only very slight corrosion was observed, and the test bars still showed a metallic luster.

Alloy No. 5, with the exception of alloy No. 2, has the lowest strength and elongation in the cast state and also after 5-yr. exposure. It is definite that 4 per cent iron is harmful. In alloy No. 3, the next highest iron is found (1.89 per cent). The tensile strength is lower than in alloy No. 4 with 1.35 per cent iron, and alloy No. 1 with 1.59 per cent iron. After 5 yr., alloy No. 3 gained some tensile strength without loss in elongation. In alloy No. 1 the tensile strength remained practically the same, but the elongation dropped from 1.4 per cent to 1 per cent. Alloy No. 2 behaved like alloy No. 3; it gained some tensile strength and lost no elongation. There seems to be little choice between 1.3 and 1.9 per cent iron as far as corrodibility is concerned, but it is apparent that the alloy containing lower iron has the higher initial properties.

Copper in the 13 per cent silicon alloy is kept at lower limits in the sand-casting and chill-casting specifications than in the 5 per cent silicon alloy, but the copper in the die-casting specification remains the same in both alloys. It is, of course, illogical to suppose that copper is more harmful in the 13 per cent silicon alloy than in the 5 per cent silicon alloy, except that probably the total amount of hardening elements should be kept as low as possible since the additional 8 per cent silicon to the 5 per cent alloy represents a considerable increase in hardening elements. As pointed out in the discussion of the 5 per cent silicon alloy, the corrosive influence of copper is considerably overrated. A closer study of Table XII confirms this statement.

The alloys containing 0.64 and 0.98 per cent copper did not lose any more of their properties during the 5-yr. exposure than did the alloys containing about 0.15 per cent or so of copper. Copper up to 0.8 per cent increases the yield strength, does not change the tensile strength, but reduces the elongation. The remarkable effect of copper on silicon alloys is the increase of the dynamic elastic properties (*33*, *49*, *58*, *168*). (These high elastic properties made this alloy also a valuable base for piston alloys.)

One of the reasons for the drop in tensile strength and elongation caused by the addition of copper to the modified 13 per cent sand-cast alloy may be that the copper counteracts the effect of the modifying agent sodium and tends to revert the structure to the normal state. Nevertheless, alloys containing 0.8 per cent copper, cast in sand, still have 22,000 to 28,000 psi. tensile strength and an elongation of 1 to 4 per cent with most of the properties found at the higher limits.

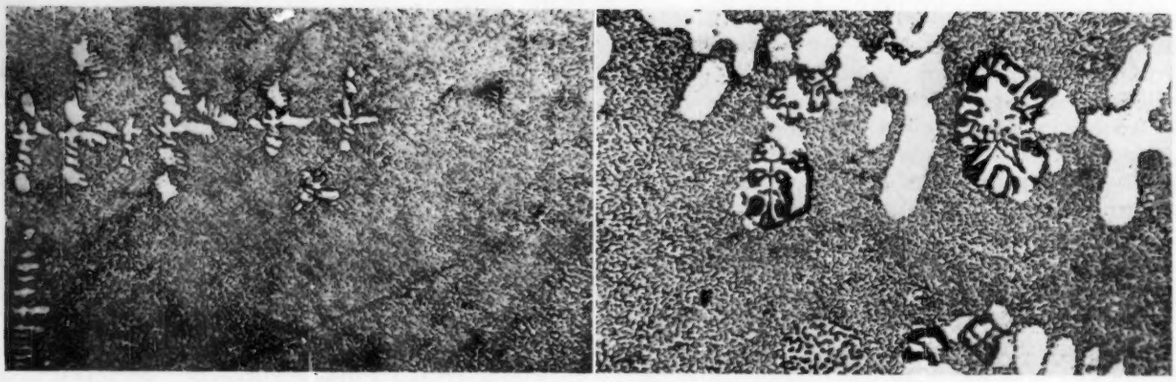
Since chill casting usually increases considerably tensile strength, elongation, and yield strength, higher properties should also be expected in this alloy when chill-cast. However, the specification indicates that although the tensile strength is higher in permanent mold than in sand casting, the elongation is lower—the more chill, the less elongation (Table XIII). This is particularly strange in the permanent mold casting in which the composition is nearly the same as in the sand casting. The high iron usually found in die castings naturally affects elongation adversely.

TABLE XIII.—MINIMUM PROPERTIES.

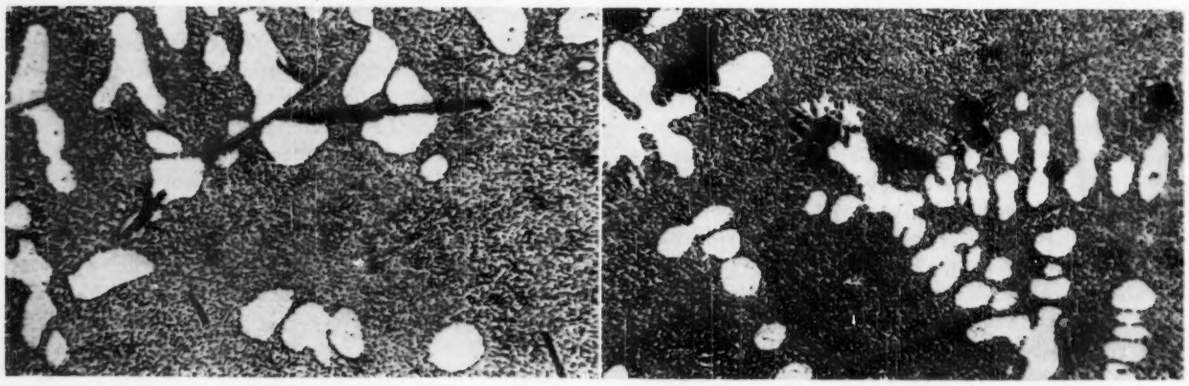
	Tensile Strength, psi.	Elongation, per cent
Sand cast	24 000	5
Permanent-mold cast	27 000	3
Die cast	33 000	1.5

Magnesium also forms Mg_2Si in this alloy and changes the properties in the same manner as in the 5 per cent silicon alloy. Its limitation to 0.05 per cent in these specifications is advisable when ductility is desired. The 0.1 per cent allowed by the die-casting specifications B 85 appears high on superficial view. However, Table XII shows that there is hardly any aging effect whether 0.12, 0.09, or 0.01 per cent magnesium is present in the alloys. Alloys with a magnesium content in the 0.10 per cent range, cast in sand or permanent mold, usually exhibit a decided tendency to age at room temperature. Therefore, it should be concluded that 0.1 per cent magnesium is not harmful in 13 per cent silicon-alloy die castings. Alloy No. 4 exhibits the greatest ductility probably because the total amount of hardening elements is only 14.6 per cent while alloys Nos. 1 and 2 contain 15.8 and 16 per cent, respectively (*48*, *56*, *58*). Magnesium renders the alloy heat treatable and has great uses in high-strength castings as will be discussed later.

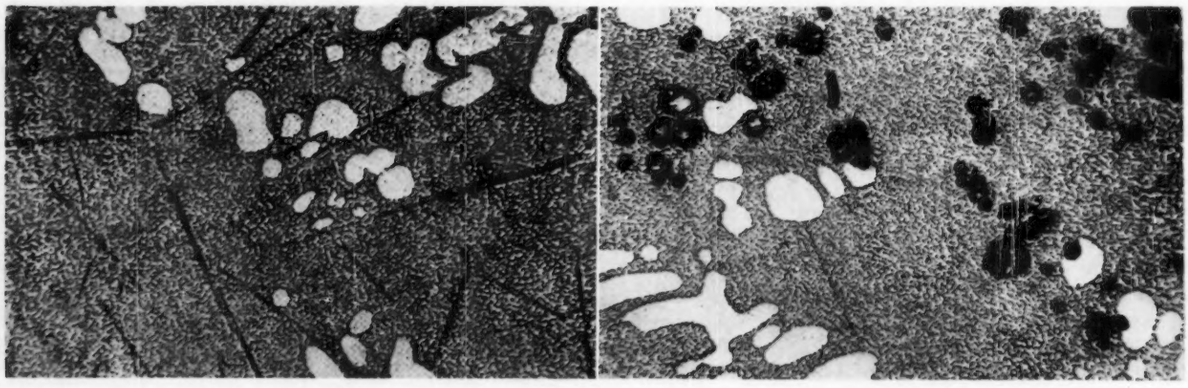
Manganese is limited to 0.2 per cent in sand castings and 0.3 per cent in permanent-mold and die castings. The reasons for this limitation can again only be adduced as a desire to keep the total hardening elements low. Its effect on this alloy seems to be very beneficial as pointed out in the discussion of the 5 per cent silicon alloy. It is said that manganese additions show no disadvantage up to 0.8 per cent. Up to 0.4 per cent it has a definite advantage, because smaller amounts of sodium are necessary for modification (*58*, *83*, *160*, *162*). Elongation, ductility in general,



0.5 per cent iron. 0.5 per cent iron plus 0.5 per cent manganese.



1.0 per cent iron. 1.0 per cent iron plus 0.5 per cent manganese.



1.5 per cent iron. 1.5 per cent iron plus 0.5 per cent manganese.

Fig. 1.—Sand-Cast 13 per cent Silicon Alloy with Additions of Iron and Manganese.

tensile strength, and yield strength are not reduced up to 0.5 per cent.

In previous discussions of the effect of manganese in aluminum alloys and, in particular, aluminum-silicon alloys, it was stated that manganese changes the harmful aluminum-iron-silicon needles to a less harmful form. Figure 1 illustrates the change of the aluminum-iron-silicon needles to a harmless Chinese script type. It is interesting to note that even with 1.5 per cent iron present, only 0.5 per cent manganese is necessary to render the iron less harmful. The illustrations[8] represent well-modified 13 per cent silicon alloy.

The *nickel* content of alloys in the 13 per cent silicon sand-casting and chill-casting specifications is included in the "total other" impurities and is kept on the order of 0.05 to 0.2 per cent. In the die-casting specification, however, it is allowed up to 0.5 per cent. Nickel, as mentioned under the discussion of the 5 per cent silicon alloy, forms a compound, Al_3Ni, which forms a ternary eutectic with the aluminum-silicon alloy at 11.8 per cent silicon and 3.9 per cent nickel (*237*). Nickel in small amounts such as 0.5 per cent is, therefore, found in the eutectic relatively finely dispersed. Nickel increases the hardness and strength at the expense of the ductility, but alloys containing even only 0.5 per cent nickel maintain these properties at elevated temperature better than alloys without nickel (*45, 171*).

[8] Taken from *Practische Metallkunde* by George Sachs.

Chromium has been added to aluminum alloys in the past few years, particularly in aluminum-magnesium, and aluminum-zinc, or aluminum-zinc-magnesium alloys. These alloys often contain between 0.15 to 0.40 per cent chromium. Some silicon alloys also carry small additions of chromium. Chromium forms a compound with aluminum, Al_3Cr. The eutectic lies very close to the aluminum, and it is said that up to 0.3 per cent chromium will go into solution during heat treatment. However, this figure seems to be rather high. Chromium is said to be beneficial, improving strength of the aluminum without adversely affecting ductility and also improving the corrosion resistance.

The effect of *zinc* has been discussed at length in the 5 per cent silicon alloy and does not need repetition here. Referring to Table XII in which alloys containing zinc from 0.03 to 0.90 per cent are found, no ill effect from zinc addition is indicated. The limitation of 0.1 per cent in the sand casting and 0.5 per cent in the chill casting is not warranted since it is nearly neutral up to 1 per cent (*58*).

Tin decreases tensile strength, elongation, and yield strength in the 13 per cent silicon alloy, but up to 0.3 per cent can be tolerated. It improves the fluidity, machinability, and the electrical and heat conductivity of the alloy. It does not form compounds with either aluminum or silicon and is present in the elementary state. In the sand-casting specification it is included in the "total other impurities" of 0.2 per cent and, therefore, very low. The die-casting specification allows 0.1 per cent tin. In the permanent-mold 13 per cent silicon alloy it may be somewhat higher since the total other impurities are 0.5 per cent maximum. In either case it seems to be held unnecessarily low (*33*, *223*).

The effect of *lead* on 13 per cent silicon has been reported as neutral on the properties of aluminum-silicon alloys when added in amounts from 0.01 to 0.5 per cent. When magnesium is present in the alloy, even 0.1 per cent lead causes a slight improvement in the alloy (*137*, *146*). Lead also has been added to improve machinability.

One element which has not been discussed so far, although it is found in many alloy specifications, is *titanium*. It is mentioned in alloys G and GG, J and JJ, N, M and 10. In all these alloys with the exception of alloy O, it is treated as an "impurity" (maximum 0.2 per cent is given) while in alloy O, 0.1 to 0.3 per cent is a required alloying element. In this alloy, as in the others, titanium additions are used as modifying or grain-refining elements. In some alloys, 0.05 per cent, in others 0.10 per cent or more will cause fine-grained aluminum crystals throughout the casting. These fine crystals in properly refined alloys are found in the thin and heavy sections of the casting even when poured at relatively high temperature. This uniformity in fine grain gives somewhat improved properties. Multitudes of small aluminum crystals, consequently, disperse the alloying elements of the eutectic much finer in the casting, resulting in greater solubility of soluble elements at heat-treating temperatures or, in other words, better heat-treatability (*81*).

This modification, however, seldom carries over from the ingot to the casting. It is lost during the melting of the ingot. Therefore, it is necessary for the greatest benefit to add titanium shortly before the pouring of the alloy into the molds. The titanium is added either as an aluminum-titanium hardener, as a flux, or as a gas. In either case it can be found in the analysis of the alloy. That is, the titanium is not lost from the alloy, as is the case with sodium which is used for modification of silicon alloys. When the scrap of the alloy is remelted, new titanium must usually be added to insure grain refinement. This causes an accumulation of titanium in the alloys.

Since grain refinement does not always result from residual titanium but only freshly added titanium, it appears that titanium is not the actual grain refiner but that a compound of titanium causes the modification. Since this refinement disappears during remelting, and particularly when the metal is fluxed, it appears reasonable to suppose that the refiner is actually nonmetallic and titanium is only the carrier of it. There is, however, no direct proof of this theory.

Titanium forms an intermetallic compound Al_3Ti, which, like iron, crystallizes in needle form and reduces tensile strength and elongation quite rapidly. Therefore, its limitation of 0.2 per cent seems justified. It also has a decided tendency to segregate and form colonies of these needles when present in larger amounts (*147*). In other words, it adds to the relatively harmful effect of iron in the alloy in direct proportion to the amount of titanium added. Manganese additions reduce the harmful effect of titanium just as it does that of iron.

The advantages which are gained by the addition of such elements as nickel, manganese, titanium, or chromium to silicon alloys can be easily lost if one does not realize that all of these elements tend to separate in the melting vessel, if the melting temperature is kept too low, or if the metal is not properly stirred after melting. It happens frequently in pouring processes where furnaces are periodically charged, but seldom completely emptied, that compounds of the heavy elements sink to the bottom of the melting vessel. Here they accumulate into a high melting sludge which might contain as high as 10 to 25 per cent iron + manganese + nickel + chromium + titanium. This can be prevented by proper charging and pouring technique.

It should be pointed out that this accumulation can be very annoying in gooseneck die-casting machines, and the metal should be watched and cared for properly. Often a slight increase in pouring temperatures will prevent such accumulation.

Group 7: Complex Aluminum-Silicon Alloys

In the foregoing sections, the two binary aluminum-silicon alloys, 5 and 13 per cent silicon, were discussed. As impurities the elements copper, magnesium, manganese, nickel, zinc, iron, lead, and tin were mentioned. However, complex silicon alloys such as the ternary, quaternary, and even more complicated alloys are used today. The elements mentioned above, with the exception, probably, of iron, appear now as desirable alloying elements; and in the A.S.T.M. specifications we find these elements are desirable: alloys M, 10, N, VI, XI, 6, and 7. However, they are not the only alloys in existence; today there are many more. Surveying all these aluminum-silicon alloys, we are able to define four basic groups.

In the first group, we have aluminum-silicon alloys to which copper, magnesium, manganese, nickel, titanium, zinc, and lead are added individually to form ternary

TABLE XIV.

Alloy	Iron, per cent	Titanium, per cent	Manganese, per cent	Tensile Strength, 1000 psi.	Yield Strength, 1000 psi.	Elongation, per cent
No. 1	0.48	0.03	0.02	26.7–29.5	15.8–17.1	6.0–7.0
No. 2	0.48	0.18	0.02	26.4–27.9	14.4–15.6	5.5–6.5
No. 3	0.46	0.18	0.32	28.0–29.0	14.0–15.8	7.0–8.0

alloys. In the second group, the complex aluminum-silicon-copper alloys, form a base for alloys to which these elements are added. The third group, aluminum-silicon-magnesium alloys, has the same additions. Finally, in the last group, more complex than the three previous groups, we find a base of aluminum, silicon, copper, and magnesium.

In each group the alloying elements added are said to have a definite function in the alloy and are very desirable. It is, of course, necessary to know in each case what properties are desired, which of the elements will produce these properties, and how much of each individual element or group of elements must be added to produce those properties.

The literature helps a great deal in the study of these alloys. In general it should be stated that in all these alloys, independent of their group, iron is not desirable in amounts larger than 1 per cent, and in some of the alloys even considerably less. Iron is definitely an impurity and not an alloying element; but by studying the individual alloys, it is possible to determine the effect of iron on each alloy. In general it can be stated that in all four groups—aluminum-silicon, aluminum-silicon-copper, aluminum-silicon-magnesium, and aluminum-silicon-copper-magnesium—the presence of iron is limited to about 0.5 per cent maximum if manganese or nickel or both are not present. Manganese, in particular, as pointed out on many occasions before, is beneficial in minimizing the harmful effect of iron. It is, therefore, logical that in alloys containing neither of these elements, manganese or nickel, the iron must be limited to possibly 0.5 per cent maximum, as is done in A.S.T.M. Specifications B 26, alloys N and M, and in B 108, alloy 10.

In the first group, aluminum-silicon alloys, we find B 26 alloys M and N, and B 108 alloy 10. Alloys M and 10 contain 6.5 to 7.5 per cent silicon, and 0.2 to 0.4 per cent magnesium. The iron content is necessarily limited, as mentioned above, to 0.5 per cent, and the manganese, zinc, and also the other elements to 0.05 per cent each, with the exception of copper which is allowed to a maximum of 0.2 per cent. Copper is limited to this low amount to make the alloy more corrosion resistant. However, as pointed out in the previous discussion on the effect of copper on silicon alloys, this amount is needlessly low and could be considerably higher without harmful effect. The same could be said about zinc, and possibly lead and tin.

To obtain the properties in the alloy, it is necessary to have the specified low iron content. Since such a low iron content is found only in pure aluminum, only such material can be used to produce the alloy. However, the present shortage of aluminum demands greater application of less pure material, and the specifications would have to be changed in many respects to make it possible to use other than pure material. This could easily be done by requiring a manganese content in the alloy of, say, 0.5 per cent, and with it, allow the iron content to increase to a maximum of possibly 1 per cent. This might be a step in the right direction.

Tests made on this alloy in regards to the effect of iron, titanium, and manganese gave very interesting results which substantiate the statement made above.

An alloy M containing relatively high iron was selected and designated alloy No. 1. Titanium was added to part of this alloy (alloy No. 2), and titanium and manganese were added to another part (alloy No. 3). These three alloys were cast in green sand and heat treated 12 hr. at 1000 F., quenched in hot water, and aged 3 days at room temperature before testing. The results are shown in Table XIV.

These tests indicate that this alloy is sensitive to iron since the elongation is on the low side of the specification. When titanium was added, a loss of strength and ductility was noticed. Finally, when manganese was added, the strength recovered and the elongation even surpassed the original which did not contain titanium. These changes in properties can be related directly to the changes in microstructure. In Fig. 2 the original alloy, alloy No. 1, shows a relatively large number of long black needles, the aluminum-iron-silicon complex. When titanium was added, alloy No. 2, these needles increased in size and caused the loss of ductility. Coring was also found in the aluminum crystals due to titanium addition. After manganese had been added, alloy No. 3, the aluminum-silicon-iron-titanium complex constituents had been finely dispersed, causing improvement in properties.

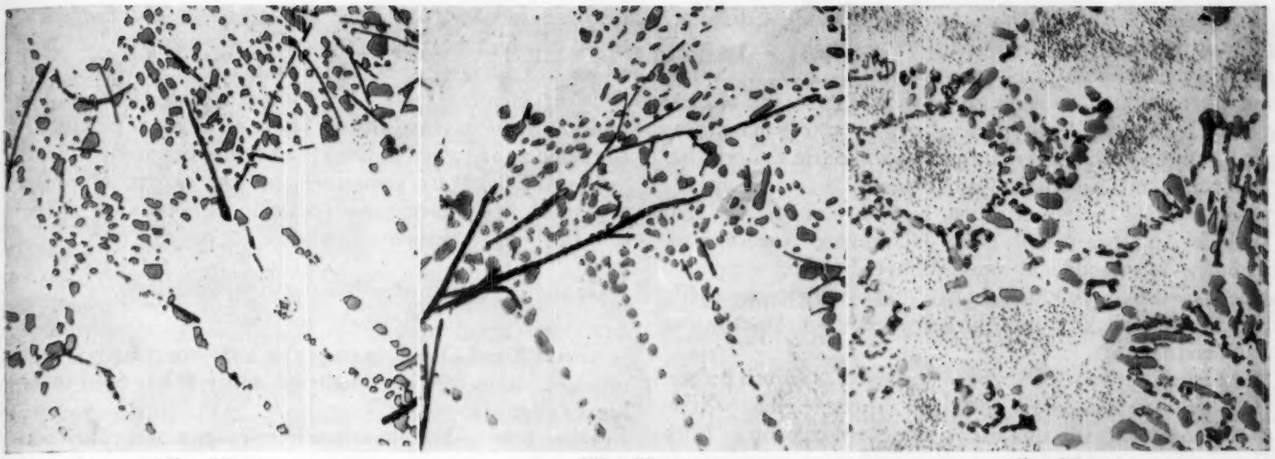
It should be concluded from these tests that:

1. Titanium acts as an equivalent amount of iron.
2. The deleterious effect of iron and titanium can be considerably minimized or greatly prevented by the addition of manganese.

The same is true in A.S.T.M. Specifications B 26, alloy N, except that here the manganese content is allowed to be 0.1 per cent maximum, and the total other elements 0.2 per cent which, in other words, does not allow more than 0.05 per cent each. In this alloy, however, the copper content is between 1 and 1.5 per cent and the silicon content is dropped to 5 per cent. This alloy is used today not only for sand casting, but also for permanent-mold casting. It is not any less corrosion resistant than alloy M, but still it is a sensitive alloy because the iron has to be kept low to insure the properties. The same arguments used in alloys M and 10 can be repeated here and changes should be made to increase the supply of raw materials.

A replacement alloy[9] for these alloys has been available and used in this country for about 8 yr. It has been made entirely out of remelt material, and its composition has been selected so that the alloy is not so sensitive regarding its iron content as the above-mentioned alloys M, N, and 10. It has been used for Diesel engine castings for some

[9] This alloy is known as Red X-8 alloy.



Alloy No. 1 Alloy No. 2 Alloy No. 3

Fig. 2.—Effect of Magnesium and Titanium on the Iron-Aluminum Complex Compounds of Alloy M (× 400). All samples were etched with Villela's etch.

TABLE XV.

	Alloy M, Chill Cast		Replacement Alloy, Chill Cast	
	Heat Treatment No. 1[a]	Heat Treatment No. 2[a]	Heat Treatment No. 1[a]	Heat Treatment No. 2[a]
Tensile strength, psi	32 000 to 44 000	41 000 to 43 000	35 000 to 42 000	40 000 to 44 000
Average	35 500	41 800	38 400	42 100
Elongation, per cent	3 to 9	2 to 3	4 to 6.5	2 to 3
Average	5.3	2.5	4.5	2.5

[a] Treatment No. 1 = 3 hr. at 965 F., quenched 2 hr. at 212 F.
Treatment No. 2 = 3 hr. at 965 F., quenched 5 hr. at 320 F.

years, and it is now being used in increasing tonnage for highly stressed war implement castings. Its composition ranges are as follows:

Copper, per cent	1.0 to 2.0
Iron, max., per cent	1.0
Magnesium, per cent	0.2 to 0.5
Manganese, per cent	0.3 to 0.5
Silicon, per cent	7.0 to 8.5
Zinc, max., per cent	0.7
Other elements, max., per cent	0.5
Aluminum, min., per cent	87.5

In this alloy all elements are balanced in such a manner that they fulfil the described function of each element. Table XV illustrates the value of this alloy as compared to alloy M as found in actual production of castings made under identical conditions in the same foundry as in the same mold. When sand cast, this alloy will produce comparative properties. Heat treated similarly but with an increased solution treatment time of 12 hr. instead of 3 hr. as for chill casting, the typical results shown in Table XVI are found. The properties of this alloy can be varied considerably by different heat treatments, and these make the alloy quite flexible for different applications.

TABLE XVI.

	Heat Treatment No. 1	Heat Treatment No. 2
Tensile strength, psi	32 000	42 000
Yield strength, psi	18 000	36 000
Proportional limit, psi	11 500	22 000
Elongation, per cent	3.5	1.3
Rockwell hardness, "E" scale	70	90

Alloy VI is no longer used commercially, and since its silicon content is rather low, it does not belong in this group. It is of interest, however, that iron up to 2.5 per cent, manganese up to 0.3 per cent, zinc up to 0.8 per cent, and nickel up to 5 per cent were permissible in this alloy.

However, alloy XI is an alloy which is much used today and which has been practically combined with alloy VII in the A.S.T.M. Emergency Alternate Provision EA-B 85a, as shown in Table XVII.

TABLE XVII.

	Alloy No. LXXIX-A Casting Alloy for Gooseneck Machine	Alloy No. LXXIX-B Casting Alloy for Cold Chamber Machine
Copper, per cent	3 to 4	3 to 4
Silicon, per cent	4.5 to 9.5	4.5 to 9.5
Nickel, max., per cent	0.5	0.5
Iron, max., per cent	2.0	1.3
Zinc, max., per cent	1.0	0.6
Manganese, max., per cent	0.5	0.5
Magnesium, max., per cent	0.10	0.10
Other elements, max. per cent { each	0.15	0.15
Other elements, max. per cent { total	0.5	0.5
Aluminum	remainder	remainder

Copper in this alloy is within reasonable limits, but silicon is spread over 5 per cent. Any number of alloys are possible within this range and, obviously, all these alloys cannot have the same properties.

Iron is higher in the gooseneck machine castings to accommodate the die caster rather than to produce quality castings. The cold-chamber machine castings only permit 1.3 per cent iron. This, undoubtedly, will give castings with greater ductility and better all-around properties.

Nickel, as in most die-casting alloys, is permissible up to 0.5 per cent, but this limit is probably seldom reached today since nickel is scarce and materials containing nickel are used only where necessary. Its effect is the same as discussed in previous alloys.

The only other difference between these two alloys is found in the *zinc* content. Alloy A allows 1 per cent zinc and alloy B only 0.6 per cent. From the previous discussion, it appears that there is no reason for limiting zinc to 0.6 per cent.

Manganese and *magnesium* have been discussed before and nothing new has to be said for these alloys.

Since the *chromium* level in these alloys is relatively low, much attention should be given to *lead*, *tin*, and *bismuth* which are carried into these alloys from free machining alloy scrap. It has been stated by some die casters that they found no difficulties which could be traced to the presence of tin in amounts even higher than 0.15 per cent (such as 0.25 per cent). This is likewise true of lead. Bismuth is not found in amounts over 0.10 per cent, and since it is used to counteract and to distribute the easily segregating lead, it should be considered beneficial rather than detrimental.

The effect of *titanium* has been discussed at length before.

Alloys Nos. 6 and 7 (B 108) contain the highest silicon of the complex silicon alloys under discussion. Both alloys are used where low expansion, high strength at elevated temperatures, and wear resistance are of prime importance. They have been used for many years in pistons and similar applications.

While alloy No. 6 permits an iron content of 1.3 per cent, Alloy No. 7 permits only 0.9 per cent. It has been found that in alloy No. 7 in complicated designs, casting difficulties are encountered when the iron content rises much over 1.0 per cent. Alloy No. 6 seldom shows an iron content as high as 1 per cent. The magnesium is considerably higher in alloy No. 6 than in alloy No. 7, still the same physical properties are obtained. The Mg_2Si which is formed has a solid solubility of 1.8 per cent at 570 C. Since, even after solution heat treatment, not all soluble Mg_2Si is in solid solution, the presence of such high amounts of magnesium is not necessary in alloy No. 7. It has been found that 0.6 per cent gives sufficient hardening and strengthening effect. Alloy No. 7 uses about 0.75 per cent manganese to get the same effect of lower expansion and strength at elevated temperature as 2.5 per cent nickel provides in alloy No. 6. Manganese is limited in alloy No. 6 and nickel in alloy No. 7 to 0.06 per cent for other than metallurgical reasons. Zinc is not harmful in either of the alloys as shown in Table XVIII.

TABLE XVIII.

Zinc, per cent	Alloy No. 6, per cent	Alloy No. 7, per cent
Tensile Strength at Room Temperature		
0.02	100.0	100.0
0.20	100.0	99.5
0.40	100.0	97.7
0.60	103.7	99.2
0.80	104.2	99.5
1.00	105.6	.....
1.20	104.0	101.0
Tensile Strength at 302 F.		
0.02	100.0	100.0
0.20	100.0	99.5
0.40	102.3	98.5
0.60	109.0	101.5
0.80	105.5	100.0
1.00	107.2	.....
1.20	107.9	100.3
Tensile Strength at 437 F.		
0.02	100.0	100.0
0.20	100.0	99.8
0.40	104.0	99.5
0.60	101.6	103.0
0.80	102.8	101.0
1.00	107.6	.....
1.20	106.0	100.0

The tensile strength of the alloy containing low zinc had been taken as 100 per cent at each temperature of testing. In alloy No. 6 even an increase of tensile strength could be observed at all temperatures when zinc had been added in relatively substantial amounts.

Other elements such as chromium and titanium are seldom found in these alloys, but their effect is practically the same as discussed in the 13 per cent silicon alloy No. 8.

Tin and lead are sometimes present or are added for machinability. Generally speaking, amounts of 0.3 per cent of the two elements combined are not detrimental.

Group 8: Aluminum-Magnesium, Aluminum-Zinc-Magnesium Alloys

Alloys L and O of Specifications B 26 are relatively new types of alloys for this country. Alloy L has been in use longer than alloy O.

Alloy L is a straight aluminum-magnesium alloy containing about 3.75 per cent magnesium. It is said to be corrosion resistant and of silvery color. Therefore, copper, iron, silicon, zinc, and the other impurities are kept at very low limits. Since magnesium in these amounts is in solid solution, heat treatability cannot be expected for this alloy especially when silicon is kept below a maximum of 0.25 per cent. Higher silicon makes this alloy somewhat easier to cast, but also more brittle. The alloy is rather hot-short and in order to cast it in permanent mold it is a recommended practice to add 1.5 per cent zinc. In the sand casting, however, zinc is limited to 0.05 per cent which gives the appearance that higher zinc is harmful. This cannot be reasonable in reference to the chill casting. Lead and tin are said to reduce the properties of this alloy and should be kept low. Manganese is allowed up to 0.6 per cent and apparently is not harmful. Iron is kept to 0.4 per cent maximum for corrosion resistance.

Alloy O is a somewhat different type of alloy. The main alloying element is zinc instead of magnesium. Magnesium is added in sufficient amounts to form some compound of $MgZn_2$ besides the Mg_2Si. This compound makes the alloy susceptible to improvement in properties by aging treatments, and properties are obtained which usually can only be obtained by solution heat treatments. This alloy has two more alloying elements which are desirable. These are chromium and titanium. Chromium in amounts of 0.4 to 0.6 per cent are said to improve the strength, particularly the yield strength without adversely affecting the elongation. Titanium is used as a grain refiner which, in this case, also reduces somewhat the hot-shortness which is inherent to all aluminum alloys that are deficient in eutectic.

Iron is tolerated up to 1.0 per cent in this alloy.

Copper is kept low to prevent corrosion.

Silicon was permitted up to 0.6 per cent, but has been reduced in the latest specification to 0.25 per cent in order to prevent the formation of an excess of Mg_2Si. If 0.6 per cent silicon were present, all of the specified magnesium would be used by the preferential formation of Mg_2Si. When silicon is below 0.25 per cent, some magnesium is left over to form $MgZn_2$ which gives this alloy its desirable properties. The amount of $MgZn_2$ formed is still very small even with silicon as low as 0.15 per cent.

Nickel, manganese, lead, tin, and all other alloying elements are said to be harmful and, therefore, specified at less than 0.05 per cent each.

The author has developed and investigated a series of

alloys which fall between alloys L and O in the proportioning of zinc and magnesium. While alloy L has high magnesium and no zinc to get optimum properties and alloy O has high zinc and relatively low magnesium, it has been found that alloys containing zinc and magnesium in such proportion as to form a ternary compound of aluminum, magnesium, and zinc have very exceptional properties. Alloys containing 6, 7, or 8 per cent of this compound, and manganese, chromium, titanium, and nickel, as desired alloying elements, can easily be cast in permanent mold and develop such properties as 36,000 psi. tensile strength and 14 to 18 per cent elongation in the as-cast condition. When aged at room or slightly elevated temperatures, properties like 45,000 psi. tensile strength, 36,000 psi. yield strength, 4 to 8 per cent elongation, or 50,000 psi. tensile strength, and 3 to 5 per cent elongation can easily be obtained without solution heat treatment.

Now it cannot be conceived from these results that more than 0.5 per cent zinc is harmful in alloy L nor that chromium and nickel are also undesirable. Neither can it be conceived that in alloy O manganese and nickel must be kept at such figures as 0.05 per cent maximum. Copper is also too low for most uses and it has been found in the author's investigations of aluminum-magnesium-zinc alloys that copper as high as 1.5 per cent is often most desirable. Iron has a surprisingly beneficial effect on these alloys with very low silicon, and limitations of 1.0 per cent might even be too low for some applications.

Lead and tin are in the same category as silicon in these alloys. Their addition or presence above 0.10 per cent of each is not recommended since they rapidly decrease the physical properties of these alloys.

Conclusion

The foregoing discussion of the effects of minor alloying elements on aluminum castings has been rather lengthy and in many places repetitious, but, unfortunately, this could not be avoided. If one considers that 14 common alloying elements are used today in aluminum alloys and that they can occur in astronomical combinations, it becomes apparent that it is impossible to have technical data available for all cases. A great deal of generalization must be resorted to, after the available information had been analyzed in the light of present-day metallurgical knowledge and practical experience. Sam Tour, in his excellent paper of 1929[4] spoke of his "impression" regarding the effect of minor alloying elements. The author would like to present this paper in the same tentative spirit. That the two papers do not agree in some phases is most likely due to the fact that we have learned much in the past decade. We are used to more complicated alloys today than we were yesteryear. Yet, no doubt, there is still ample room for diverse opinion and discussion. The die-casting field, especially, presents relatively little information in the literature, and much metallurgical guesswork had to be resorted to.

It is well realized that, under present conditions, systematic studies of die-casting alloys or, for that matter, all aluminum alloys, cannot be conducted; but the author is certain that when peace rules the world again such studies will bring fruitful results.

In conclusion the author wishes to express his gratitude to the members of the American Society for Testing Materials' Sub-subcommittee on Impurities of Subcommittee II of Committee B-7 on Light Metals and Alloys, Cast and Wrought for their assistance in compiling the bibliography. Also to The National Smelting Company for their kindness in putting their test records and all facilities so generously at the author's disposal.

Outstanding Philadelphia Meeting Planned for October 28 with Nationally Prominent Scientists Present

The second in the current series of meetings sponsored by the Philadelphia District Committee will be held at the Franklin Institute on October 28, and will feature four scientists who have done work of national and international prominence in their respective fields—these four people cooperating in this session because of a joint interest in the application of notable developments in microscopy.

Dr. F. F. Lucas, Research Microscopist, Bell Telephone Laboratories, Inc., will be the chief speaker, covering some of his latest industrial work in the field of biology and hevea, balata and synthetic latices, discussing particularly new color techniques. Through his interest three outstanding authorities in certain health fields will participate—Dr. John F. Mahoney, Senior Surgeon, U. S. Public Health Service, Director V. D. Research Laboratory, U. S. Marine Hospital, Stapleton, S. I., and his associate, Dr. R. C. Arnold, will speak and show micro-motion films of the various stages in the life cycle of the syphilis spirochete. These two men are among the leading authorities on syphilis in the country. This will be the first showing of these films to an engineering group.

The third speaker with whom Dr. Lucas has been associated and who is a leading authority on a subject in which almost every person is concerned—cancer, is Dr. Mary B. Stark, N. Y. Medical College and Flower Hospital, New York, who will describe the application of the ultraviolet microscope to the study of living cells. She has done outstanding work in cancer research. A popular article describing some of her work and some of its conclusions appeared in the September 4 issue of *Liberty* magazine in an article entitled "Is Cancer Hereditary?"

J. R. Townsend, Materials Standards Engineer, Bell Telephone Laboratories, Inc., and A.S.T.M. Vice-President, will be the presiding officer at the meeting, and the Philadelphia District Committee has received the acceptance of an invitation to Dr. Hubley R. Owen, head of the Philadelphia City Department of Health to speak.

All A.S.T.M. members and committee members in the Philadelphia area will receive further details about the meeting but notice is served to be early, because an overflow attendance is expected. Invitations are being extended to many chemists and chemical engineers in the Philadelphia area and to the medical fraternity, doctors, nurses, and health officials.

The Philadelphia Committee is indebted to Dr. Lucas for his interest in helping to arrange the meeting, and is pleased to have acceptance from the national authorities who are participating.

ASTM Bulletin

OCTOBER 1943

NO. 124

TWO-SIXTY
SOUTH BROAD ST.
PHILADELPHIA, PENNA.

Materials Inspectors! *****?

SOME COMMENTS about the inspection of materials might be made. Certainly there has been considerable in the past few months in the daily and technical press about inspection and quality of materials.

Those who write specifications are cognizant of inspectors because a constant cry is "Write the specifications so that they can be understood by the inspector," the assumption being that the inspector was the kind of person who couldn't understand some kinds of language.

We have heard comments from different sources on the almost obstructionist practice followed by some inspectors who seem fearful of accepting material unless almost perfect.

In *The Iron Age* of September 9, J. H. Van Deventer writes on "Death Penalty for Inspectors," in which he refers to a certain bill introduced in Congress which would impose the death penalty or a fine of a mere $1,000,000. The editorial points out that the present penalty for a war fraud involving defective materials is 30 years in prison. The conclusion "if 30 years on the rock pile is not a deterrent, then the death penalty would not be either" seems sound. He points out that even A.S.T.M. in many cases must compromise on certain points using the phrase "as agreed upon by the manufacturer and purchaser," and "thus even experts cannot agree on what is defective and what is not." While we would prefer to have that qualified to read *frequently* cannot agree, we do not quibble with the "death penalty article," but feel that some comments are in order.

Let's take the emergency specifications for certain carbon and alloy-steel heavy forgings covering particularly materials for turbines, generators, etc. These were desired quickly. There were no standards, as such. To get the specifications approved the committees responsible decided in several instances that they must leave certain matters subject to agreement—not necessarily, however, involving defects. No one likes this situation—least of all our A.S.T.M. committee people, and in most cases specific requirements are given—but there are some matters that have to be left to judgment or agreement. Probably no specification can ever cover completely all defects, and on almost any materials' problem, judgment and common sense are essential. One famous engineer said "Specifications must be interpreted on the broad lines of *professional intelligence*."

The basic objective is that the material *serve its intended use satisfactorily*, and all too frequently, we fear, this point is overlooked by an inspector and perhaps also by the producer.

Hundreds of millions of dollars worth of products have been turned out faster than ever before in the war effort but since recent investigations, many inspectors have felt they must protect themselves by being unnecessarily critical. This is a most serious situation, evident when war production executives found it necessary to make statements urging common sense in the inspection process.

One thing is certain in connection with materials inspection—the more *common sense* there is, and the more intelligence, the more efficient will be our production output. There are all too few materials inspectors—and altogether too much for these few to do. The inspectors have tremendous responsibility, and by and large they have discharged it well. The compared-with-the-total small number of cases where arbitrariness has ruled are unfortunate. This whole problem in wartime is immensely complicated.

We are sure that with the cooperation of the producer, the inspector, and the buying agency—these three—any inspection problem can be satisfactorily resolved.

To District Committee Members—and *All* Our Members

ONE OF OUR A.S.T.M. District Committees recently arranged for a meeting, expecting an attendance of about 200 persons. More than 600 people came.

The subject of Plastics, which was under consideration at the meeting, is of much interest to a great many people. There has been a very rapid development of this broad class of products both as substitutes for metals and also for new uses for which they are uniquely adapted.

In these days when so many changes are taking place in the availability of materials, we are all interested in any new developments which may help in our work, and we are willing to go to some trouble to find out about them, when we learn of such an opportunity.

Our District Committees, therefore, have an opportunity to be of real service by arranging for meetings on live subjects. This will be of much benefit to our members and to the Society, and also will aid in the War Program. Many of our District Committees have recognized this opportunity, but I believe that there is still much more that can be done.

There are many excellent subjects which can be developed into interesting and profitable discussions. For example:

- Powder Metallurgy
- Protection against Corrosion
- The Theory and Use of Specifications
- Plastic Research
- Testing and Paint Inspection Problems, etc.
- Aircraft Materials

To Our 150 Members of District Committees:

A few thoughts on plans for meetings may be mentioned:

The A.S.T.M. Staff is ready and anxious to help you in planning and arranging for meetings. Consult them.

Obviously a subject of broad educational interest should be stressed.

The speaker "makes" or "breaks" a meeting. He must *know* his subject, and must be able to present it in an interesting manner.

The meeting must be publicized *thoroughly*. People will come if they know about it. It must be announced in and outside A.S.T.M. A live publicity chairman is essential.

These are obvious elements of any meeting that is to be successful—*but* sometimes they are neglected.

The attendance at the meeting alone is no criterion of its success. Many factors may affect the attendance. The important thing is that those present feel repaid for participating.

A well-planned meeting with a live subject and speakers will do much good, and be well worth while, even *though* the attendance is not large.

Every District Committee should have at least one meeting per year, and more if it seems advisable. I am planning to assist you in every way that I can and shall arrange to attend your meetings whenever possible.

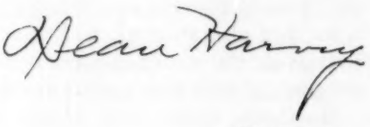
Now a Word to All of Our Members:

Our District meetings can be made a very vital part of our work in promoting knowledge of materials and developing and promoting the use of satisfactory purchase specifications and testing procedures.

Your local District Committee needs your active support in arranging for meetings, in advertising them, and aiding in bringing out a large attendance.

These District meetings can provide a good means for you to get up-to-date on current developments.

We must remember that many of our people cannot regularly attend the Annual and Spring Meetings. It is the District Meetings that bring A.S.T.M. close to them. It means much to you and to the Society to have good meetings on subjects of interest. We are counting on your support.



President.

Offers of Papers for 1944

COMMITTEE E-6 on Papers and Publications in anticipation of developing the program for the 1944 Annual Meeting is desirous that members of the Society and others who have in mind submitting offers of technical papers should send these offers to Society Headquarters well in advance of the February meeting of the committee (about Feb. 21). All offers must be accompanied by a summary which should make clear the intended scope of the paper and indicate features that, in the opinion of the author, will justify its inclusion in the annual meeting program. Suitable blanks to be used in transmitting the necessary information will be sent promptly on request.

There are certain points which might well be kept in mind in connection with this matter—first, that the committee in charge does not judge the contribution on the basis of length or comprehensiveness of the paper. A review of A.S.T.M. *Proceedings* will indicate that a very large number of pertinent and important contributions are short or relatively so, although of course there are numerous items that are extensive. Another point is this—with the ASTM BULLETIN available for publication of papers there need be no delay in publishing and disseminating items that would lose some of their value if publication were in the *Proceedings* which usually comes out at the end of the year.

There has been no diminution in the number of offers of papers for Annual Meetings and for publication in the BULLETIN—an indication that American industry and Government departments concerned with materials are continuing to foster research; and much of it directly relates to the war effort.

Schedule of A.S.T.M. Meetings

DATE	COMMITTEE	PLACE
October 20–22	D-13 on Textile Materials	New York, N. Y.
October 24	D-3 on Gaseous Fuels	St. Louis, Mo.
October 25	E-9 on Research	Columbus, Ohio
October 26, 27	D-9 on Electrical Insulating Materials	New York, N. Y.
October 27...	Subcommittee XIII on Coal Sampling, of Committee D-5	Pittsburgh, Pa.
October 28, 29	D-20 on Plastics	New York, N. Y.
October 28...	PHILADELPHIA DISTRICT	Philadelphia, Pa.

Favorable 1943 Standards Letter Ballot

A CANVASS on September 10 of the 1943 letter ballot on recommendations affecting A.S.T.M. standards showed all items on the ballot adopted. There were 72 actions covered, 20 revisions of existing standards were adopted for incorporation this year, and 52 previously existing tentative standards were adopted as formal standards. Over 450 votes were cast and while in accordance with previous practice no record of the returns will be published, any member of the Society who wishes to have the vote on a particular item can obtain this information from A.S.T.M. Headquarters.

All of the new and revised standards will appear in the 1943 Supplements to the Book of A.S.T.M. Standards. In many cases previous to the appearance of the books (December) separate reprints of many of the specifications and tests will be available and a number of them will be incorporated in special compilations of standards which are described in a new pamphlet, "List of Publications" and "Members' Order Blank" which will be sent to members shortly.

Secretary-Treasurer Appointed Consultant, WPB Conservation Division

IN LINE with the decision of the A.S.T.M. Executive Committee that it would be necessary for the Secretary-Treasurer to give substantially more of his time to the work and responsibilities of A.S.T.M. thus devoting less time to his work in the WPB Conservation Division, Mr. Warwick tendered his resignation as Chief of the Materials Branch and on August 28 this was accepted by Mr. Coonley, Conservation Division head, and Mr. Warwick was appointed as Consultant in the Division.

Since early in 1941 Mr. Warwick has been active in WPB work, becoming Chief of the Specifications Branch and of its successor, the Materials Branch, and had been devoting about 80 per cent of his time to this work and to the National Emergency Steel Specifications project of which he is administrator. Since it was impossible for him to carry on the work as Chief of the Materials Branch with the time he could allot, he felt it necessary to resign, but is continuing his connections with the work. His new duties include general administrative supervision of specification work with Federal Specifications Committees, Army, Navy and other Government Agencies, as well as contacts with industrial specification organizations; also responsibility for the Specifications Library and records. He will continue as Administrator of National Emergency Steel Specifications Project and serve in a consulting capacity on the work in the construction field, in this capacity heading for the Conservation Division, the Advisory Committee on Conservation in Construction.

In accepting the Secretary-Treasurer's resignation Mr. Coonley wrote:

"I realize, however, the important part that the American Society for Testing Materials has assumed in the past and will take in the future, both in our war effort and in our peacetime economic progress. I recognize, also, the pivotal position you hold in the A.S.T.M., and therefore the necessity of your giving more time to its activities."

For the immediate future Mr. Warwick plans to devote about half his time to WPB activities.

Another change in the Conservation Division that will be of interest to members is the merging of the Materials and Products Branches into one group under the head of Mr. R. B. Shepard, who is now Assistant Director of the Division. No Division Deputy Director has as yet been appointed.

1943 Volume Gives A.S.T.M. Methods of Chemical Analysis of Metals

THE 1943 VOLUME of "A.S.T.M. Methods of Chemical Analysis of Metals" has been issued (after some unexpected and unavoidable delay) and provides in their latest approved form recommended practices for apparatus and reagents, analytical procedures for ferrous and non-ferrous metals and spectrochemical analysis methods. This volume supplants the one issued in 1940 and, of course, is an adjunct to the Book of Standards, since it is the only place where these analytical procedures appear, aside from their availability in separate pamphlet form.

The 332-page volume gives two sampling methods, 17 standard and tentative methods of which four are for the analysis of ferrous metals, ten for non-ferrous, and three cover quantitative spectrochemical procedures for non-ferrous metals. An important new feature is the Tentative Recommended Practice for Apparatus and Reagents for Chemical Analysis of Metals (E 50). Other helpful material published as information gives methods for the chemical analysis of special brasses and bronzes, and of white metal bearing alloys; also a procedure for aluminum in solder metal, and methods of sampling wrought metals and alloys for determination of chemical composition.

The responsibility for the technical content of this book rests in Committee E-3 on Chemical Analysis which in 1935 was made responsible for all of the work in this field, and Committee E-2 on Spectrographic Analysis. A quite detailed subject index (22 pages) has been included to increase the utility of the publication.

Copies of the volume have been forwarded to those members whose requests were received; extra copies can be purchased by members at $2 per copy and by nonmembers at $3 each. The binding is blue cloth in conformity with the Book of Standards.

1943 "Selected A.S.T.M. Standards for Students in Engineering"

THE LATEST edition of the book "Selected A.S.T.M. Standards for Students in Engineering" was issued in August, 1943, with 8000 copies printed. Originally it had been planned to issue the book every two years, but for the past three or four years extra editions have been issued and the number of copies printed has been greatly in excess of what had been originally contemplated. Since 1937, 35,000 copies of the book have been printed, which bespeaks its widespread use. It has increased in size considerably—the 1930 edition had 160 pages; August, 1943, 265 pages. A large number of technical and engineering schools giving courses in materials technology, testing laboratory, specifications, and such subjects use this book as a laboratory guide and supplement to texts in their classes.

The object of the original committee of engineering faculty members which made the first selection of standards was to provide a representative group of commercial tests, and also through inclusion of certain specifications to provide the future engineer with a good conception of a commercial purchase specification.

Standards, either tests or specifications, in the current book cover cement, aggregates, concrete, brick, timber, and various ferrous and non-ferrous metals. The latest items added in the August, 1943, edition are a specification for phenolic molding compounds and one for tensile strength of molded electrical insulating materials. There is a total of 39 standards.

The book gives information about the Society and its publications, and includes exerpts from the classic 1907 Presidential Address by Charles B. Dudley entitled "Factors and Principles Involved in the Enforcement of Specifications." A complete list of Honorary Members, past-presidents, and Edgar Marburg lecturers is given with principal industrial affiliations, and in the case of Honorary Members and Presidents their academic background.

In recent revisions of the book H. J. Gilkey, Head, Department of Theoretical and Applied Mechanics, Iowa State College, assisted by Dr. Glenn Murphy, Associate Professor, have cooperated closely.

With a large number of the ESMWT. (Engineering Science and Management War Training) courses involving inspection and testing and related problems, this book has found very practical application in providing authoritative information. The Executive Committee, desirous that the book be readily available to any student, maintains a special price of 50 cents per copy on orders for 10 or more copies. The price to non-students is $1.00 per copy.

Stimulate Use of Tests for Askarels

COMMITTEE D-9 on Electrical Insulating Materials through its Subcommittee IV on Liquid Insulation has for many years carried on intensive work involving various tests such as the sludge test, neutralization number, gas content of oil, electrical properties, etc. During the past year the scope of the work has been extended to include standards for synthetic insulating liquids known as *Askarels*. Detailed methods have been published in the 1943 report covering sampling, specific gravity, color, pour point, refractive index, and other properties. The committee is very desirous that users should become cognizant of the test methods and make use of them. One of the reasons why the committee would especially like to have consumer reaction is the possibility that these methods may be proposed in 1944 for acceptance as an A.S.T.M. tentative standard. A limited number of copies of these methods are available at A.S.T.M. Headquarters, and a copy will be sent without charge to anyone who is concerned.

Committee D-17 on Naval Stores Expands Its Work; Members Invited to Serve

THE SCOPE and lines of work of Committee D-17 on Naval Stores have been expanded to take in several new items for standardization and new subcommittees have been provided for and chairmen appointed as follows:

Subcommittee V on Specifications and Analysis of Tall Oil (Liquid Rosin), Arthur Pollak, *chairman*, West Virginia Pulp and Paper Co., Charleston, S. C.

Subcommittee VI on Specifications and Testing of Pine Tar and Tar Oil, J. P. Bain, *chairman*, Southern Pine Chemical Co., Jacksonville, Fla.

Subcommittee VII on Terpene Hydrocarbons and Pine Oil, I. E. Knapp, *chairman*, Crosby Naval Stores, Inc., Picayune, Miss.

Matters relating to turpentine will be handled by Subcommittee VII. It will initiate action on any revision of the turpentine specifications as well as to prepare new specifications covering other terpene hydrocarbon solvents, and will cooperate closely with D-1's new Subcommittee V on Volatile Solvents for Organic Protective Coatings. Committee D-1 will exercise final jurisdiction over turpentine and this class of solvents for protective coatings.

At the meeting of Committee D-17 held in Pittsburgh in June an Advisory Committee was appointed to aid in administering committee work. Four members in addition to the D-17 officers will serve—the complete personnel is as follows: V. E. Grotlisch, *Chairman*, U. S. Department of Agriculture; E. V. Romaine, *Vice-Chairman*, The Glidden Co.; W. A. Kirklin, *Secretary*, Hercules Powder Co.; *Members:* Jerome Boyer, Newport Industries, Inc.; R. E. Pflaumer, The Resinous Products and Chemical Co., Inc.; Arthur Pollak, West Virginia Pulp and Paper Co.; C. C. Zeigler, Swift and Co.

Members Invited to Serve:

Any members of the Society who are not now represented on Committee D-17 but who may be interested in the standardization of specifications and testing methods for the materials covered by the above subcommittees, as well as in any other phase of naval stores (pine tree products) testing as indicated by the other subcommittees of Committee D-17 (I on Softening Point of Rosin; II on Crystallization of Rosin; III on Volatile Oils in Rosin; and IV on Acid and Saponification Numbers and Unsaponifiable Matter of Rosin) are invited to become members of the standing committee.

A letter requesting such representation on the committee and designating the subcommittee with which the applicant wishes to collaborate, should be sent to the secretary of the committee, W. A. Kirklin, Hercules Powder Co., Experiment Station, Wilmington, Del.

Conservation Charts for Aluminum, Brass, and Bronze Castings

THE AUGUST BULLETIN in the description of the Material Substitution and Supply List No. 9 as released by the WPB Conservation Division referred to an aluminum alloy substitution chart which in compact form gives pertinent information aimed to stimulate use of scrap and secondary metals and conserve virgin aluminum. The chart covers sand, permanent-mold, and die castings.

On September 11 there was released a revised conservation chart covering brass and bronze castings showing specifications and material requirements. The original chart was published in the January BULLETIN, page 48, with detailed description of the more salient factors. Carter S. Cole, Chief of the Metals Branch, WPB Conservation Division, and very active in A.S.T.M. work, who developed the information has commented as follows:

"Designing engineers have utilized the previous chart in making specification changes that have made efficient use of our supplies of secondary and scrap material. In nine months, during which foundry output has increased 17 per cent, the use of new copper by ingot makers and foundrymen has decreased 22 per cent. That represents an achievement in conservation which is saving thousands of tons of primary copper per month.

"Since the publication of the original chart in January, the material supply situation has changed. Today, tin-bearing copper-base alloy scrap is much less readily available. On the other hand, fired cartridge cases are being returned from the battle fields in quantities in excess of that which can be readily used by the brass mills. These make excellent material for the ingot maker in compounding regular manganese bronze.

"Consequently, in this reissue of the chart, emphasis is placed on the desirability of changes into manganese bronze and yellow brass and less emphasis is placed on the changes into the secondary tin-bearing copper-base alloys.

"The title of the chart has been changed from Down-Grading to Conservation to emphasize the fact that it illustrates the true definition of conservation—namely, the effective use of our materials and resources. Actually, some of the properties of the alloys suggested as substitutions are superior to those of the alloys that they can replace. Manganese bronze, for instance, is a higher strength alloy than Composition "G" or "M." It does not, however, have the same properties as a bearing metal, or the same resistance to certain types of corrosion, nor is it useful for intricate pressure castings.

"It is of interest to note that recent specification changes, looking toward standardization of alloys, have narrowed the yellow brass specifications to the three covered by Federal Specification QQ-B-621 and A.S.T.M. Specification B 146. Other specification changes have been made since the chart was first issued so that today the specifications as listed approach a standardization never before achieved in the industry."

XXXIII. Long-Time Society Committee Members

Thirty-third in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM BULLETIN comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general, the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.

Herbert Spencer

W. H. Herschel

W. J. Krefeld

HERBERT SPENCER, President, The Asphalt Institute, New York, N. Y., and a graduate in 1903 with the degree of Civil Engineer from Rensselaer Polytechnic Institute, was engaged in railroad surveys in Central and South America and later was Assistant Engineer on the construction of New York State Barge Canal. In 1907–1908 he was Resident Engineer, New York State Highway Department.

At this time the automobile was beginning to exact its toll from the gravel and macadam roads of that period. Experiments were started and materials discussed for dust elimination and Mr. Spencer made trips to California and other western locations to investigate the so-called "road oil" used at that time. As a result, he was instrumental in developing the use of asphalt materials on New York State highways, particularly the Long Island roads. This was the beginning of the era of highway work in the United States, and realizing the need for developing both a satisfactory asphalt product and its proper uses, Mr. Spencer joined the Standard Oil Co. of New Jersey as an Engineer in the newly created Asphalt Department. This work took him to all sections of the country, conferring with many engineers on specifications for asphalt materials. Committee D-4 of the A.S.T.M. was in its infancy about this time, and Mr. Spencer, as a member of the Society since 1909 and of Committee D-4 since its formation, has taken part in many of its discussions. He has also served on Committee D-8 on Bituminous Waterproofing and Roofing Materials, and was for a number of years affiliated with Committee D-18 on Soils for Engineering Purposes.

He was Captain and Commanding Officer of Co. H, 23rd U. S. Engineers in World War I and served overseas on road construction in the advance zone of operations.

In 1941, Mr. Spencer retired from the Standard Oil Co. of New Jersey and since that time has acted as President of The Asphalt Institute.

He is a member of the American Road Builders' Assn., Association of Asphalt Paving Technologists, Engineers' Club of New York, Army and Navy Club of Washington, D. C., and the Upper Montclair Country Club.

W. H. HERSCHEL, long-time Physicist and Materials Engineer, National Bureau of Standards, Washington, D. C., who has recently retired, is a native of Boston, Mass., where his father, Clemens Herschel, had been President of the Boston Society of Engineers, and American Society of Civil Engineers, and was the inventor of the Venturi meter. A graduate of Harvard College, he was first employed by the East Jersey Water Co. which constructed the enlarged water supply for the city of Newark. During the years 1904 and 1905 he was representative of certain American companies in Zurich, Switzerland, and on return to this country was engaged in steam turbine design and later was a member of the faculty at the University of Maine. Since 1913 he has been at the Bureau of Standards.

His membership in A.S.T.M. dates from 1915, and he has been a member of a large number of committees, notably D-2 on Petroleum Products and Lubricants, where for a great many years he was chairman of the Subcommittee on Viscosity. He has been a member of the Committee on Plasticity and Consistency of Committee E-1 on Methods of Testing, and made a notable contribution in this field in connection with the translation of the French classic paper of Poiseuille on flow through very small tubes, which is basic in our knowledge of viscosity. Dr. Herschel has also contributed papers to various technical publications, including A.S.T.M. PROCEEDINGS. For example, in the years 1916 through 1919 he had four technical papers dealing with petroleum problems, including viscosity of lubricating oils, gasoline, and a quantitative test for resistance of lubricating oils to emulsification.

W. J. KREFELD, Associate Professor of Civil Engineering, Columbia University, and Director of Civil Engineering, Research Laboratories, Columbia University, New York, N. Y., was born in New York City, was graduated from Columbia in 1914 and since 1917 has been affiliated with Columbia. He was Engineer of Tests prior to his present position. He has been engaged in a large variety of fundamental and industrial research investigations and now is conducting research associated with war work, on impact resistance of welded beams and physical properties of treated wood construction, in addition to ESMWT training courses and Navy College Training Program.

Professor Krefeld has been a member of the A.S.T.M. since 1918, and serves on a number of committees, including C-11 on Gypsum, C-5 on Fire Tests of Materials and Construction, and C-15 on Manufactured Masonry Units. He is chairman of the latter's Subcommittee IV on Sand-Lime Brick. He was also a member of the former committees C-3 on Brick and C-10 on Hollow Masonry Building Units which committees merged in 1937 forming the present Committee C-15. Professor Krefeld also serves on several sectional committees of the American Standards Association, and is a member of the A.S.T.M. New York District Committee.

He is a member of the Subcommittee on Fire Resistive Construction for the New York Building Code and of the Advisory Committee for Revision of New York State Labor Code on Fire Resistive Construction. He is a member of several other societies in addition to A.S.T.M., including American Society of Civil Engineers, American Concrete Institute, American Welding Society, Society for the Promotion of Engineering Education, National Society of Professional Engineers and is Past President of the New York County Chapter of the New York State Society of Professional Engineers.

Comments from Forty-Year Members

SEVERAL of the so-called 40-year members—those who as of 1943 had been affiliated with the Society for forty years—were unable to attend the Annual Meeting in Pittsburgh and receive their engrossed certificate, so these were mailed. A number of interesting comments have been received from these men. Because of their wide circle of friends and associates in the Society and, too, the nature of some of the communications, excerpts from a few appear below. The August BULLETIN included a list of the 1943 forty-year members.

Leon S. Moisseiff, Consulting Engineer, New York, N. Y.: (We regret to announce Mr. Moisseiff's death, see Necrology item in this BULLETIN).

"I regret that I will miss the pleasure of meeting old friends at this for us memorable occasion. My thoughts go back to the young years of the Society when, under the enthusiastic leadership of Professor Marburg, it began its efforts for scientific testing and standardized specifications. It rose with the growth of scientific engineering, and has attained now unhoped for proportions of usefulness and influence. During these past forty years the meetings of the Society, its papers and discussions have been a rich source of information for me. With pleasure I remember the many gatherings where engineering thought and experience were exchanged in an atmosphere of friendliness which encouraged the younger men and elated the older. We all have learned from it. May the coming generations be as fond of it as we, the older, are."

C. E. Skinner, now with the U. S. Army Signal Corps, Red Bank, N. J., who about ten years ago was retired as Director of Engineering, Westinghouse Electric and Manufacturing Co.:

"In my work here I frequently find it necessary to consult our volumes of A.S.T.M. specifications and perhaps just as frequently to refer to the fundamentals of specification writing as outlined in the classical addresses on the subject by dear old Dr. Dudley. I am trying to utilize my experience in Westinghouse, the A.S.T.M., the A.I.E.E., and my international work, in the writing of specifications and the establishing of standards. I have always enjoyed and found profitable my contacts with A.S.T.M."

Maximilian Toch, President, Toch Brothers, Inc., Staten Island, N. Y.

"I should like you to know that I deeply appreciate the honor the Society has bestowed on me, and that I have placed the certificate in a conspicuous spot on the wall of my office."

C. P. Van Gundy, Retired, Engineer of Tests, Baltimore and Ohio R. R. Co., Baltimore, Md.:

"I am glad to have this as it will serve to remind me of many pleasurable and profitable hours spent at the various meetings. (There was some hard work at times, also.)"

Roger C. Griffin, Vice-President, Arthur D. Little, Inc., Cambridge 42, Mass.

"I just want to let you know that our certificate of Forty-year Membership arrived today in good condition, and we are proud to possess it. Our policy has been that support of the leading technical societies should not merely be of a passive, financial nature but should include as far as possible the active service of members of its staff in the activities of these societies. For many years we have made it a practice to assign individual members of our staff to one or more societies. I feel that I have been particularly fortunate that one of my assignments has been A.S.T.M.

At every meeting of A.S.T.M. or of any of its committees which I have attended I have always been impressed by the earnestness and ability of the members and have made many contacts which have developed into real friendships. This is one of the dividends of active participation in the work of technical societies. May I take this opportunity to wish for A.S.T.M. continued prosperity and success in the work it has so well carried on up to the present in coordinating and distributing technical information in the engineering fields."

Steel for Testing

PROVISIONS of CMP Regulation No. 1 with respect to delivery of sample orders of steel for testing purposes have been modified to permit purchasers to receive up to 1000 lb. of any one composition or a total of 3000 lb. of all compositions. This applies to all types of steel except stainless, tool steel, and steel castings.

Sample order delivery requirements for testing purposes on all other controlled materials, including stainless steel, tool teel, and steel castings, continue to be limited to one per cent of the minimum mill quantity which is prescribed with respect to the various types of controlled materials in Schedule IV of CMP Regulation No. 1.

This ruling is contained in Amendment No. 2 to CMP Regulation No. 1, issued August 4, 1943.

SOLVES MANPOWER SHORTAGE: In Corona, Cal., one man is city engineer, city purchasing agent, superintendent of streets, manager of the sewage treatment plant, superintendent of parks, and coordinator of civilian defense. He has just completed a survey of several hundred vacant lots and will supervise elimination of their fire hazards. This municipal official also has a victory garden on the vacant lot adjoining his home and raises chickens and rabbits in his spare time.—News Bulletin from Public Administration Clearing House. (Seems this fellow is almost as busy as some of our A.S.T.M. members.)

Mildew-Resistance at Textile Meeting

A SYMPOSIUM on Mildew-Resistance, with four technical papers will feature the papers session of Committee D-13 on Textile Materials at the Park Central Hotel, New York, on Thursday, October 21, at 2 p.m. The evaluation of fabric treatments for resistance to mildew is extremely important and the committee plans to arrange for discussion of the papers. They will cover such topics as developing and standardizing test methods for mildew-proofing and rot-resistance of textiles, evaluating fabric treatments by pure culture methods, by soil suspension methods, and by soil burial methods. Committee D-13 is having a three-day series of meetings, October 20 to 22.

New Members to September 27, 1943

The following 101 members were elected from July 16 to September 27, 1943:

Chicago District

BARBER-COLMAN CO., T. W. Alder, Standards Engineer, 150 Loomis St., Rockford, Ill.

BARBER-GREENE CO., Guy Banister, Chief Engineer, 631 W. Park Ave., Aurora, Ill. (Sustaining Member)

MINNEAPOLIS-HONEYWELL REGULATOR CO., AERO DIVISION, Carl W. MacNeil, Inspector in Heat Treating and Plating Depts., 1135 N. Cicero Ave., Chicago 51, Ill.

SANDEE MANUFACTURING CO., William L. Hess, Assistant General Manager, 3945 N. Western Ave., Chicago, Ill.

AMRINE, LECLARE HAMER, President, Imperial Molded Products Corp., Chicago, Ill. For mail: 532 Roscoe St., Chicago 13, Ill.

BRINEN, HOWARD F., Research Engineer, Young Radiator Co., 709 Marquette St., Racine, Wis.

TOMPKINS, E. J., Metallurgical Engineer, Central Steel and Wire Co., 3000 W. Fifty-first St., Box 5310-A, Chicago 80, Ill.

Cleveland District

PARKER APPLIANCE CO., THE, R. C. Fuhrman, Laboratory Director, 17325 Euclid Ave., Cleveland, Ohio.

WEBER DENTAL MANUFACTURING CO., THE, H. E. Nelius, Chief Engineer, 2206 Thirteenth St., N. E., Canton 5, Ohio.

HOAGLAND, RICHARD HAVIS, Metallurgist, Canton Naval Ordnance Div., Westinghouse Electric and Manufacturing Co., Radd Road, S. W., Canton 1, Ohio.

HODGE, J. C., Vice-President, The Wellman Engineering Co., 7000 Central Ave., Cleveland 4, Ohio.

KRISTOFF, LOUIS, Chief Metallurgist, National Aluminum Cylinder Head Co., Cleveland, Ohio. For mail: 9610 Dickens Ave., Cleveland 4, Ohio. [J]*

OEHLER, IRVING A., Chief Metallurgist, American Welding and Manufacturing Co., Warren, Ohio.

PRINCE, WARREN V., Plastics Engineer, The Weatherhead Co., 300 E. 131st St., Cleveland 8, Ohio.

THOMPSON, JAMES R., Manager, Metallurgical Dept., American Steel and Wire Co., 1446 Rockefeller Bldg., Cleveland 13, Ohio.

TRUMBULL, A. G., Chief Mechanical Engineer, The Chesapeake & Ohio Railway Co., 1038 Midland Bldg., Cleveland 1, Ohio.

VAN DUSEN, C. H., JR., Chief Chemist, Addressograph-Multigraph Corp., Euclid, Ohio. For mail: 56 Barber Ave., Willoughby, Ohio.

Detroit District

LANDERS CORP., THE, C. E. Denoon, Jr., Development Manager, Box 911, Toledo 1, Ohio.

CHAPMAN, RICHARD D., Metallographer, Chrysler Corp., Detroit, Mich. For mail: 5960 Bishop, Detroit 24, Mich.

CLARK, ROY A., Chief Metallurgist, E. W. Bliss Co., Toledo, Ohio. For mail: 920 Alvison Road, Toledo 12, Ohio.

GOLDBLATT, ALAN, Spectrographer, Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.

HODGE, EDWIN S., Spectrographer, Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.

SCHUCH, JOHN, Chief Spectrographer, Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.

New York District

ANSONIA ELECTRICAL CO., THE, A. P. Lunt, Chief Chemist, 63 Main St., Ansonia, Conn.

BOONTON MOLDING CO., G. K. Scribner, President, 326 Myrtle Ave., Boonton, N. J.

FORD RADIO AND MICA CORP., J. J. Long, President, 536 Sixty-third St., Brooklyn 20, N. Y.

GERING PRODUCTS, INC., Everett R. Gordon, Chief Chemist, Monroe Ave. and Gering Place, Kenilworth, N. J.

KLETT MANUFACTURING CO., Theodore J. La Manna, Manager, 177–179 E. Eighty-seventh St., New York, N. Y.

ONYX OIL AND CHEMICAL CO., Saul Kaplan, Chemist, 15 Exchange Place, Jersey City 5, N. J.

PLASTICS MANUFACTURERS, INC., K. D. Browne, Secretary-Treasurer, 280 Fairfield Ave., Stamford, Conn.

SCIENTIFIC CONCRETE SERVICE CORP., R. F. Moss, Vice-President, 1252 Waverly Place, Elizabeth, N. J.

SIKORSKY AIRCRAFT, DIVISION OF UNITED AIRCRAFT CORP., M. E. Gluhareff, Chief of Design and Research, South Ave., Bridgeport 1, Conn.

SOCIETY OF THE PLASTICS INDUSTRY, William T. Cruse, Executive Vice-President, 295 Madison Ave., New York 17, N. Y.

TECH-ART PLASTICS CO., Roy E. Berg, Vice-President and General Manager, 41-01 Thirty-sixth Ave., Long Island City 1, N. Y.

BONANNO, JOSEPH LOUIS, Chief Engineer, The Lionel Corp., Irvington, N. J. For mail: 56 Woodland Rd., Madison, N. J.

DEBELL, GEORGE W., Consulting Engineer, Gurley Bldg., Stamford, Conn.

DORIAN, MICHAEL A., Chief Chemist, Roxalin Flexible Finishes, Inc., 800 Magnolia Ave., Elizabeth F, N. J.

HORROCKS, ROBERT I., Assistant Chief Chemist, Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J. For mail: 271 Williams Ave., Hasbrouck Heights, N. J. [J]

HUFF, THOMAS D., Chemist, The Watson-Stillman Co., Box 26, Roselle, N. J.

SEELIG, RICHARD PAUL, Chief Engineer and Metallurgist, Powder Metallurgy Corp., Long Island City, N. Y. For mail: 89-10 Whitney Ave., Elmhurst, Long Island, N. Y.

SHERRER, W. A., Spectrographer, Harry W. Dietert Co., 1060 Broad St., Newark 2, N. J.

WEILLER, PAUL G., Head of Research Dept., Kollsman Instrument Division of Square D Co., Elmhurst, Long Island, N. Y. For mail: 38-02 Sixty-first St., Woodside, Long Island, N. Y.

Philadelphia District

BIXLER, A. L. M., Chemical Engineer, Riegel Paper Corp., Warren Mill, Riegelsville, N. J.

BOOTH, JAMES H., Naval Air Experimental Station, Aeronautical Engine Lab., Bldg. 600, Naval Air Material Center Philadelphia, U. S. Navy Yard, Philadelphia 12, Pa. [J]

CONTINO, PETER J., Steel Chemist, Carnegie-Illinois Steel Corp., Pencoyd, Pa. For mail: 316 S. Fifty-sixth St., Philadelphia 43, Pa.

EDELMAN, NORMAN B., Assistant Technologist, Philadelphia Quartermaster Depot, Philadelphia, Pa. For mail: 5740 Osage Ave., Philadelphia 43, Pa.

HEILIGMAN, H. A., Head, Technical Dept., E. J. Lavino and Co., Box 29, Norristown, Pa.

LANDT, GUSTAVE E., President, Philadelphia Textile Finishers, Inc., 3701 N. Broad St., Philadelphia 40, Pa.

ROTH, H. A., Chief Chemist, Rundle Manufacturing Co., 3905 River Ave., Camden, N. J.

SANNER, JOHN P., Tinius Olsen Testing Machine Co., Philadelphia, Pa. For mail: 380 Fairfax Rd., Drexel Hill, Pa.

SELDEN, JOHN K., Director, Berlin Lab., Owens-Illinois Glass Co., P. O. Drawer F, Berlin, N. J.

Pittsburgh District

NATIONAL ANNEALING BOX CO., A. J. Luppino, Chief Engineer, Baird Ave. and B. & O. R. R., Washington, Pa.

COCHENOUR, GEORGE E., JR., Inspector of Army Ordnance, U. S. Army, 46 Tretow St., Pittsburgh 14, Pa.

FIX, E. LESTER, Assistant Director of Research, Pittsburgh Plate Glass Co., Works No. 17, Creighton, Pa.

FRYE, R. A., Engineer, Engineering Labs. and Standards Dept., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

GEORGE, W. J., Assistant to the President, Edgewater Steel Co., Box 478, Pittsburgh 30, Pa.

KIRKPATRICK, J. A., Superintendent of Inspection, Ellwood Works, National Tube Co., Ellwood City, Pa.

St. Louis District

WABASH RAILROAD CO., J. C. Bousfield, Chief Engineer, 1402 Railway Exchange Bldg., St. Louis, Mo.

PAXTON, E. W., Director of Research, Mississippi Glass Co., Main and Angelica Sts., St. Louis 7, Mo.

Southern California District

ARMSTRONG, CECIL W., Senior Research Engineer, Lockheed Aircraft Corp., Burbank, Calif. For mail: 918 E. Santa Anita, Burbank, Calif.

FREES, BENJAMIN MARSH, JR., Process Engineer, Northrop Aircraft, Inc., Northrop Field, Hawthorne, Calif. For mail: 220 Sixteenth St., Hermosa Beach, Calif. [J]

SOLOW, HENRY A., Metallurgist and X-Ray Analyst, X-Ray Products Corp., Los Angeles, Calif. For mail: 1800 N. La Brea Ave., Hollywood 46, Calif.

WILDES, EDWARD WALDO, Assistant Metallurgical Engineer, Adel Precision Products Corp., Burbank, Calif. For mail: 472 Norman Ave., Arcadia, Calif.

Western New York-Ontario District

MINNIS, WESLEY, Assistant Director of Research and Development, National Aniline Division, Allied Chemical and Dye Corp., 1051 S. Park Ave., Box 975, Buffalo 5, N. Y.

SHERIDAN, SIDNEY A., Head, Materials Lab., Airplane Division, Curtiss-Wright Corp., Airport Plant, Buffalo, N. Y. For mail: 401 Parkside Ave., Buffalo, N. Y.

U. S. and Possessions

Other than A.S.T.M. Districts

AERO TEST LABORATORY, E. W. Swedien, Chief Test Engineer c/o Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis 8, Minn.

DOUGLAS FIR PLYWOOD ASSN., J. D. Long, Chief, Research Dept., 301 Tacoma Bldg., Tacoma 2, Wash.

GENERAL ELECTRIC CO., Howard Miller, Engineer, Works Lab., 1635 Broadway, Fort Wayne 2, Ind.

GULF STATES UTILITIES CO., Thomas E. Crossan, Superintendent of Production, Box 2431, Louisiana Station, Baton Rouge 2, La.

HOOPER AND SONS CO., WILLIAM E., Harry B. Beck, Research Engineer, 3500 Parkdale Ave., Baltimore 11, Md.

LORD MANUFACTURING CO., Hugh V. Strong, Chief Chemist, 1635 W. Twelfth St., Erie, Pa.

NATIONAL ROSIN OIL AND SIZE CO., E. A. Brennan, Chemist, Savannah, Ga.

NORTHERN INDUSTRIAL CHEMICAL CO., Hans H. Wanders, Vice-President, 7-11 Elkins St., South Boston 27, Mass.

NORTHWEST AIRLINES, INC., J. J. Harrington, Specifications Engineer, 1885 University Ave., St. Paul 4, Minn.

STOW MANUFACTURING CO., W. G. Baird, Development Engineer, 445 State St., Binghamton 3F, N. Y.

BADGER, IRVIN S., Eastern Representative, Metropolitan Paving Brick Co., Canton, Ohio. For mail: 742 Ostrom Ave., Syracuse 10, N. Y.

BARR, ROBERT HARRISON, Engineering Assistant, Continental Motors Corp., Muskegon, Mich. For mail: 428 River St., Spring Lake, Mich. [J]

BIBERSTEIN, FRANK A., JR., Associate Professor of Civil Engineering, and Director of Materials Testing Lab., The Catholic University of America, Washington, D. C. For mail: 27 Seaton Place, N. E., Washington 2, D. C.

BISHKO, HAROLD, Chemical Engineer, Du-Lite Chemical Corp., River Road, Middletown, Conn.

CONWELL, WALTER L., Director, College of Engineering, Cornell University, Ithaca, N. Y.

GUMM, H. W., Manager, Houston Branch, The Refinery Supply Co., 1309 Capitol Ave., Houston 2, Tex.

MARKOVITS, HOWARD MORTON, Director of Research, Olympia Wood Preserving Co., Box 14, Olympia, Wash. [J]

MAVIS, FREDERIC THEODORE, Professor and Head, Department of Civil Engineering, and Acting Head, Department of Engineering Mechanics, The Pennsylvania State College, 204 Main Engineering Bldg., State College, Pa.

MEHRINGER, FRANK J., Instructor of Mechanical Engineering, Massachusetts Institute of Technology, Room 1-212, Cambridge 39, Mass.

MILLS, ROSCOE E., Assistant Professor of Civil Engineering and Associate, Engineering Experiment Station, Materials Testing Lab., Purdue Univ., West Lafayette, Ind.

MOEHRL, KENNETH E., Research Engineer, Layne & Bowler, Inc., Box 215, Hollywood Station, Memphis 8, Tenn.

PEPIN, A. J., Chief Metallurgist, Wyman-Gordon Co., Box 789, Worcester 3, Mass.

RAYMOND, JACK D., Engineer, Glenn L. Martin-Nebraska Co., Modification Center No. 8, Fort Brook, Nebr. For mail: 3316 Dewey Ave., Omaha 5, Nebr.

UHL, W. F., President, Charles T. Main, Inc., 201 Devonshire St., Boston 10, Mass.

WILSON, CLAUDE L., Director and Professor of Mechanic Arts, Prairie View State College, Box A-1, Prairie View, Tex.

WYMAN, LEROY L., Research Metallurgist, Research Lab., General Electric Co., Schenectady, N. Y. Temporarily with War Metallurgy Committee, Washington, D. C. For mail: 41 Ray St., Schenectady 5, N. Y.

YEOMAN, R. C., Research and Sales Engineer, Texas Foundries, Inc., Lufkin, Tex.

Other than U. S. and Its Possessions

ARMSTRONG, WOOD AND CO., C. A. Meadows, Chief Engineer, 62 Richmond St., West, Toronto, Ont., Canada.

OTTAWA CAR AND AIRCRAFT LIMITED, E. W. Marshall, Chief Inspector, 301 Slater St., Ottawa, Ont., Canada.

BUTEAU, AMEDEE, Principal, Hull Technical School, 109 Wright St., Hull, P. Q., Canada.

COLLITT, BERNARD, Metallurgist, Jenkins Bros. Limited, 617 St. Remi St., Montreal, P. Q., Canada.

DACORSO, G. F., Chemical Engineer, Brazilian National Steel, Volta Redonda, E. do Rio, Brazil. [J]

DURBAN, CORPORATION OF THE CITY OF, H. A. Smith, City and Water Engineer, Box 1547, Durban, South Africa.

GALLIVAN, JOHN D., III, Box 64, Balboa, Canal Zone. [J]

GILL, A. F., Assistant to the President, National Steel Car Corp., Ltd., Hamilton, Ont., Canada.

KEAN, ARTHUR D., Sutton-Horsley Co., Ltd., Leaside, Toronto, Ont., Canada. For mail: 28 Eglinton Ave. East, Toronto, Ont., Canada.

* [J]—Denotes Junior Member.

Personals

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

The International Nickel Co., Inc., has announced certain changes in the personnel of its Development and Research Division: T. H. WICKENDEN, since 1931 Assistant Manager of the Division has been appointed Manager; and H. J. FRENCH, who is serving temporarily in the Steel Division, War Production Board, has been named Assistant Manager of the Division. Mr. French has been in charge of alloy steel development since 1932.

JAMES DRISCOLL who was formerly affiliated with Johns-Manville Corp. as Research Engineer is now Research Development Engineer, General Cable Corp., Bayonne, N. J.

J. A. BATY, who was in Charge of Analytical Laboratories, U. S. Rubber Co., Passaic, N. J., and very active in the work of Committee D-11 on Rubber Products, is now Chemist, The C. P. Hall Co., Akron, Ohio.

E. I. VALYI, formerly Associate, Materials and Process Engineering, Lucius Pitkin, Inc., 47 Fulton St., New York 7, N. Y., is now Vice-President, Sam Tour and Co., Inc., 65 Pine St., New York 5, N. Y.

ARTHUR W. F. GREEN is now Materials Engineer, Pratt & Whitney Aircraft Corp. of Missouri, Kansas City, Mo. He was Materials Engineer, N. A. Woodworth Co., Ferndale, Mich.

HERBERT P. DAUNHEIMER, formerly President, Springfield Sand and Tile Co., Inc., Springfield, Mass., is now with the Pawtucket Ready Mixed Concrete Co., Pawtucket, R. I.

KAM N. KATHJU, formerly Consulting Chemist, Arco Co., Cleveland, Ohio, has been appointed Technical Director of the same company.

R. K. BOWDEN, formerly Manager, Metallurgical Department, Chicago District, Carnegie-Illinois Steel Corp., Chicago, Ill., has been transferred to Pittsburgh as Director of Quality Control, Research and Technology Department, while L. J. ROHL, formerly Assistant Manager of the Metallurgical Department, Chicago District, succeeds Mr. Bowden as Manager.

GEORGE TERRY HORTON, engineer and inventor, and President, Chicago Bridge and Iron Co., Chicago, Ill., was guest of honor at a luncheon on July 27 to receive honorary membership in the Chicago Engineers' Club. Mr. Horton is the nineteenth member of the Club to receive honorary membership.

COLONEL BRADLEY DEWEY, President, Dewey & Almy Chemical Co., Cambridge, Mass., has been named Director of the Office of the Rubber Director, succeeding William M. Jeffers. He had served as Deputy Director since September, 1942.

DONALD L. COLWELL has been appointed Coordinator of Conservation in the U. S. Navy Department's Office of Procurement and Material, according to an announcement received from Vice Admiral S. M. Robinson. He was formerly Deputy Chief, Materials Branch, WPB Conservation Division, and previous to that a technical executive with companies producing die castings. He has taken a very active part in A.S.T.M. work, particularly Committee B-6 on Die-Cast Metals and Alloys but is concerned with the activities of other metals groups as well.

T. A. WRIGHT, formerly Technical Director and Secretary, Lucius Pitkin, Inc., New York, N. Y., has been elected President. John Jicha and Robert H. Bell have been elected Vice-President and Chemical Director, and Vice-President and Research Director, respectively. The Pitkin Laboratories, which are in their fifty-eighth year of service as chemists and engineers to the mining and metal industries, some time ago added a department of mineralogy and metallurgy and have pioneered in the application of spectrography to the determination of metals.

Catalogs and Literature Received

W. H. & L. D. Betz, Gillingham and Worth Sts., Frankford, Philadelphia 24, Pa. A six-page folder entitled "Chemical Treatment of Boiler Water" by John Drew Betz—Technical Paper No. 84. Gives sections covering problems and causes, corrosion, carryover, embrittlement, internal treatment, external treatment, etc. Also a paper entitled "Chemical Treatment of Cooling Water" by W. A. Tanzola—Technical Paper No. 85. This gives sections covering scale formation, supplementary treatment, corrosion, biological fouling, chemicals used, etc.

Mixing Equipment Co., Inc., 1084 Garson Ave., Rochester 9, N. Y. An eight-page folder entitled "Lightnin—Laboratory Mixers" Catalog B-77. Describes various types of "Lightnin" mixers and what they can do for you; tells which mixer to choose. Illustrated.

Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich. A four-page folder describing the Dietert Moisture Teller which furnishes a rapid method of drying and wide range of materials. Illustrated.

Precision Scientific Co., 1730 N. Springfield Ave., Chicago, Ill. Catalog 600 entitled "Laboratory Utilities," 112 pages, profusely illustrated. A laboratory utility is defined as an appliance which can be put to work advantageously in connection with scientific research or control and its use is not normally restricted to standard procedure. Items from the table of contents indicate the general type of material described, including, baths, burners, centrifuges, clamps, digestion, extraction, filter pumps, hot plates, ovens, pump sieves, sterilizers, stills, stirrers, timers, and numerous other pieces of laboratory apparatus. Includes alphabetical and numerical indexes.

Papers on Design of Welded Structures and Cures of Welding Troubles

Although it is not feasible in the Bulletin to abstract or even list technical papers that would be of definite concern to the very diverse interests represented in the A.S.T.M. membership, occasionally there are items which are so outstanding some note might appropriately be made. Two such papers are in the September, 1943 *Welding Journal* of the American Welding Society, 29 W. 39th St., New York 18, N. Y.

The first paper by H. Malcolm Priest, entitled "The Practical Design of Welded Steel Structures," gives through discussion and illustrations a very excellent conception of the welding processes, with of course, particular emphasis on design, as the title indicates, but even for the engineer who is not directly concerned with welding problems this paper is worth studying. Concisely written and splendidly illustrated, it is the type of paper which is outstanding from the general standpoint, and at the same time of value to the welding specialist.

C. H. Jennings, Welding Engineer, Westinghouse Electric & Manufacturing Co., in a short but pertinent discussion covers the causes and cures of fourteen common welding troubles, with photographs illustrating good and poor practices. Causes and cures are itemized in the text.

Anyone concerned with steel welding design or in maintaining a general grasp of welding as related to the materials field would find these two papers decidedly worth reading.

NECROLOGY

We announce with regret the death of the following five members:

William B. Geiser, Chief Chemist, New York Central System, Collinwood, Ohio. Member since 1923.

J. A. Jovanovits, Director, Swiss Testing House, St. Gallen, Switzerland. Member since 1935.

Charles T. Main, Engineer (Designer of Industrial Plants), Boston, Mass. Member since 1921. Mr. Main held membership on Committee D-18 on Soils for Engineering Purposes from 1939 to 1941.

Paul Rapp, Associate Chemist, Public Roads Administration, Federal Works Agency, Washington, D. C. Member since 1937. At the time of his death Mr. Rapp was a member of Committee D-4 on Road and Paving Materials, and of D-18 on Soils for Engineering Purposes, Subcommittee II on Classification of Soils, and was Chairman of Subcommittee IV on Methods of Testing the Physical Characteristics of Soils. He had also been appointed to the newly formed Joint Subcommittee of Committees D-4 and D-18 on Tests and Specifications for Stabilized Soils. He also represented Committee D-18 on Subcommittee XIII on Hydrogen Ion Determinations of Committee E-1 on Methods of Testing.

Leon S. Moisseiff, Consulting Engineer, New York, N. Y. Member since 1903. Mr. Moisseiff, world famous bridge and structural designer, whose name was linked with many of the greatest bridges, had been a member of Committee A-1 on Steel for a number of years, serving on its Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock. He had also served on Committee C-2 on Reinforced Concrete. At the June A.S.T.M. meeting Mr. Moisseiff was tendered his Forty-year Certificate, and an excerpt from his letter of thanks appears elsewhere in this Bulletin.

Complete List of A.S.T.M. Emergency Specifications and Emergency Alternate Provisions

EDITOR'S NOTE.—To provide a readily accessible and convenient reference for members who wish to have a complete list of all emergency specifications and emergency alternate provisions (pink slips) each issue of the BULLETIN will give the latest list at the time the BULLETIN goes to press. This feature suggested by the Executive Committee will appear as the last page or two of BULLETIN text immediately preceding the professional card page in the back advertising section.

October 6, 1943

Emergency Specifications for[1]

ES–1a	Lead-Coated and Lead-Alloy Coated Copper Wire for Electrical Purposes.
ES–2	Lead Coating (Hot-Dip), on Iron or Steel Hardware.
ES–3	Conducting Salt Spray Tests on Organic Protective Coatings. (Method)
ES–4	*Discontinued*, Replaced by Standard Hardness Conversion Table for Cartridge Brass. (Relationship Between Diamond Pyramid Hardness, Rockwell Hardness, and Brinell Hardness) (E 33–42)
ES–5a	Carbon-Chromium Ball and Roller-Bearing Steels.
ES–6	Rubber Sheath Compound for Electrical Insulated Cords and Cables Where Extreme Abrasion Resistance Is Not Required.
ES–7	Fire-Refined Copper for Wrought Products and Alloys.
ES–8	85 Per Cent Magnesia Thermal Insulating Cement.
ES–9	Long Fiber Asbestos Thermal Insulating Cement.
ES–10	Mineral Wool Thermal Insulating Cement.
ES–11	Expanded or Exfoliated Mica Thermal Insulating Cement.
ES–12	Diatomaceous Earth Thermal Insulating Cement, for Use from 600 to 1200 F.
ES–13	Diatomaceous Earth Thermal Insulating Cement, for Use from 1200 to 1900 F.
ES–14	Blanket Thermal Insulation for Building Purposes.
ES–15	Blanket Thermal Insulation for Industrial Purposes.
ES–16	Blanket Thermal Insulation for Refrigeration.
ES–17	Preformed Pipe Covering Thermal Insulation.
ES–18	Preformed Block Thermal Insulation.
ES–19	Structural Board Thermal Insulation.
ES–20	Malleable Iron Flange, Pipe Fittings, and Valve Parts.
ES–21	Carbon-Steel and Alloy-Steel Forgings for Magnetic Retaining Rings for Turbine Generators.
ES–22	Alloy-Steel Forgings for Nonmagnetic Coil Retaining Rings for Turbine Generators.
ES–23	Carbon-Steel Forgings for Rings for Main Reduction Gears.
ES–24	Carbon-Steel and Alloy-Steel Forgings for Pinions for Main Reduction Gears.
ES–25	Carbon-Steel and Alloy-Steel Forgings for Turbine Generator Rotors and Shafts.
ES–26	Carbon-Steel and Alloy-Steel Forgings for Turbine Rotors and Shafts.
ES–27	Carbon-Steel and Alloy-Steel Forgings for Turbine Bucket Wheels.
ES–28	Chloroprene Sheath Compound for Electrical Insulated Cords and Cables.
ES–29	Special Quality Aluminum Die Castings.
ES–30	Chloroprene Sheath Compound for Electrical Insulated Cords and Cables when Extreme Abrasion Resistance Is Not Required.
ES–31	Electrodeposited Coatings of Lead on Steel.
ES–32	Method of Test for Color of U. S. Army Motor Fuel (All-Purpose) by Means of an A.S.T.M. Color Standard
ES–33	Insulated Wire and Cable: Heat-Resisting Synthetic Rubber Compound
ES–34	Insulated Wire and Cable: Performance Synthetic Rubber Compound

Emergency Alternate Provisions in Specifications for[2]

Steel

EA–A 1	Open-Hearth Carbon-Steel Rails (A 1–39).[7]
EA–A 21	Carbon-Steel Axles for Cars and Tenders (A 21–39).[8]
EA–A 25a	Wrought Steel Wheels for Electric Railway Service (A 25–41).[2]
EA–A 26	Steel Tires (A 26–39).[6]
EA–A 27	Carbon-Steel Castings for Miscellaneous Industria Uses (A 27–42).[5]
EA–A 53	Welded and Seamless Steel Pipe (A 53–42).[10]
EA–A 57	Multiple-Wear Wrought Steel Wheels (A 57–39).[7]
EA–A 67	Steel Tie Plates (A 67–33).[7]
EA–A 70	Carbon-Steel Plates for Stationary Boilers and Other Pressure Vessels (A 70–42).[13]
EA–A 83	Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83–42).[8]
EA–A 87	Carbon-Steel and Alloy-Steel Castings for Railroads (A 87–42).[8]
EA–A 89	Low-Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities (A 89–43).[13]
EA–A 116	Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116–39).[13]
EA–A 120	Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120–42).[8]
EA–A 121	Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A 121–39).[13]
EA–A 134	Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134–42).[8]
EA–A 135	Electric-Resistance-Welded Steel Pipe (A 135–42).[8]
EA–A 139a	Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139–42).[11]
EA–A 148a	Alloy-Steel Castings for Structural Purposes (A 148–42).[11]
EA–A 158	Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158–42 T).[12]
EA–A 160	Axle-Steel Bars for Concrete Reinforcement (A 160–39).[7]
EA–A 161	Seamless Low-Carbon and Carbon-Molybdenum Steel Still Tubes for Refinery Service (A 161–40).[8]
EA–A 167a	Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip (A 167–43).[13]
EA–A 177	High-Strength Corrosion-Resisting Chromium-Nickel Steel Sheet and Strip (A 177–42).[7]
EA–A 178	Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178–40).[8]
EA–A 179	Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes (A 179–42).[8]
EA–A 183	Heat-Treated Carbon- and Alloy-Steel Track Bolts and Nuts (A 183–40 T).[7]
EA–A 186	One-Wear and Two-Wear Wrought Steel Wheels (A 186–39).[7]
EA–A 190	Lightweight and Thin-Sectioned Gray-Iron Castings (A 190–40).[7]
EA–A 192	Seamless Steel Boiler Tubes for High-Pressure Service (A 192–40).[8]
EA–A 194	Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service to 1100 F. (A 194–40).[6]
EA–A 199	Seamless Cold-Drawn Intermediate Alloy-Steel Heat-Exchanger and Condenser Tubes (A 199–40).[8]
EA–A 200	Seamless Intermediate Alloy-Steel Still Tubes for Refinery Service (A 200–40).[8]
EA–A 206	Seamless Carbon-Molybdenum Alloy-Steel Pipe for Service at Temperatures from 750 to 1000 F. (A 206–42 T).[12]

[1] Available in separate pamphlet form.

[2] Available as "pink slips" affixed to each of the separate respective specifications and published in various issues of the ASTM BULLETIN as indicated by footnotes.

[5] March, 1942 ASTM BULLETIN.
[6] May, 1942 ASTM BULLETIN.
[7] August, 1942 ASTM BULLETIN.
[8] October, 1942 ASTM BULLETIN.
[9] December, 1942 ASTM BULLETIN.
[10] January, 1943 ASTM BULLETIN.
[11] May, 1943 ASTM BULLETIN.
[12] August, 1943 ASTM BULLETIN.
[13] To be published in the December Bulletin. Meanwhile, available separately.

EA–A 209 Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 209–42).[8]
EA–A 211 Spiral-Welded Steel or Iron Pipe (A 211–40).[8]
EA–A 213 Seamless Alloy-Steel Boiler and Superheater Tubes (A 213–42).[8]
EA–A 214a Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes (A 214–42).[13]
EA–A 215 Carbon-Steel Castings Suitable for Fusion Welding for Miscellaneous Industrial Uses (A 215–41).[5]
EA–A 216 Carbon-Steel Castings Suitable for Fusion Welding for Service up to 850 F. (A 216–42 T).[6]
EA–A 217 Alloy-Steel Castings Suitable for Fusion Welding for Service from 750 to 1100 F. (A 217–42 T).[6]
EA–A 226 Electric-Resistance-Welded Steel Boiler and Superheater Tubes for High-Pressure Service (A 226–40).[8]
EA–A 235 Carbon-Steel Forgings for General Industrial Use (A 235–42).[10]
EA–A 236a Carbon-Steel Forgings for Locomotives and Cars (A 236–42).[5]
EA–A 237 Alloy-Steel Forgings for General Industrial Use (A 237–42).[10]
EA–A 238 Alloy-Steel Forgings for Locomotives and Cars (A 238–42).[8]
EA–A 240a Corrosion-Resisting, Chromium and Chromium-Nickel Steel Plate, Sheet and Strip for Fusion-Welded Unfired Pressure Vessels (240–42).[13]
EA–A 241 Hot-Worked High-Carbon Steel Tie Plates (A 241–41).[7]
EA–A 244 Heat-Treated Wrought Steel Wheels (A 244–42).[7]
EA–A 249 Atomic-Hydrogen-Arc-Welded and Electric-Resistance-Welded Alloy-Steel Boiler and Superheater Tubes (A 249–42).[8]
EA–A 250 Electric-Resistance-Welded Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 250–41 T).[8]

Non-Ferrous Metals and Alloys

EA–B 8 Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft (B 8–41).[10]
EA–B 12 Copper Bars for Locomotive Staybolts (B 12–42).[10]
EA–B 19 Cartridge Brass Sheet, Strip, and Disk (B 19–42 T).[10]
EA–B 22 Bronze Castings for Turntables and Movable Bridges and for Bearing and Expansion Plates of Fixed Bridges (B 22–40 T).[10]
EA–B 23a White Metal Bearing Alloys (Known Commercially as "Babbitt Metal") (B 23–26).[10]
EA–B 30 Copper-Base Alloys in Ingot Form for Sand Castings (B 30–42 T).[7]
EA–B 32a Soft Solder Metal (B 32–40 T).[10]
EA–B 36 Brass Sheet and Strip (B 36–41 T).[10]
EA–B 60 Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent (B 60–41).[7]
EA–B 62 Composition Brass or Ounce Metal Castings (B 62–41).[7]
EA–B 85a Aluminum-Base Alloy Die Castings (B 85–42).[11]
EA–B 86a Zinc-Base Alloy Die Castings (B 86–41 T).[9]
EA–B 100 Rolled Copper-Alloy Bearing and Expansion Plates for Bridge and Other Structural Uses (B 100–40).[10]
EA–B 103 Phosphor Bronze Sheet and Strip (B 103–42).[10]
EA–B 111 Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111–42).[10]
EA–B 121 Leaded Brass Sheet and Strip (B 121–41).[10]
EA–B 122 Copper-Nickel-Zinc and Copper-Nickel Alloy Sheet and Strip (B 122–39 T).[10]
EA–B 124 Copper-Base Alloy Forging Rods, Bars, and Shapes (B 124–42 T).[10]
EA–B 129 Cartridge Brass Cartridge Case Cups (B 129–40 T).[10]
EA–B 130 Gilding Metal Sheet and Strip (B 130–41 T).[10]
EA–B 131 Gilding Metal Bullet Jacket Cups (B 131–40 T).[10]
EA–B 133 Copper Rods, Bars, and Shapes (B 133–42 T).[10]
EA–B 134 Brass Wire (B 134–42 T).[10]
EA–B 135 Miscellaneous Brass Tubes (B 135–42 T).[10]
EA–B 139 Phosphor Bronze Rods, Bars, and Shapes (B 139–42 T).[10]
EA–B 143 Tin-Bronze and Leaded Tin-Bronze Sand Castings (B 143–42 T).[7]
EA–B 144 High-Leaded Tin-Bronze Sand Castings (B 144–42 T).[7]
EA–B 145 Leaded Red Brass and Leaded Semi Red Brass Sand Castings (B 145–42 T).[7]
EA–B 146 Leaded Yellow Brass Sand Castings for General Purposes (B 146–42 T).[7]
EA–B 148a Aluminum-Bronze Sand Castings (B 148–42 T).[10]
EA–B 151 Copper-Nickel-Zinc Alloy Rod and Wire (B 151–42 T).[10]
EA–B 152 Copper Sheet, Strip, and Plate (B 152–41 T).[10]
EA–B 159 Phosphor Bronze Wire (B 159–42 T).[10]
EA–B 169 Aluminum Bronze Sheet and Strip (B 169–41 T).[10]
EA–B 171 Copper-Alloy Condenser Tube Plates (B 171–42 T).[10]

"C" and "D" Groups

EA–C 150 Portland Cement (C 150–42).[1]
EA–D 27a Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27–41).[6]
EA–D 69a Friction Tape for General Use for Electrical Purposes (D 69–38).[12]
EA–D 119 Rubber Insulating Tape (D 119–38).[10]
EA–D 147 Methods of Testing Bituminous Mastics, Grouts, and Like Mixtures (D 147–41)[13]
EA–D 224a Asphalt Roofing Surfaced with Powdered Talc or Mica (D 224–41 T).[7]
EA–D 228 Methods of Testing Asphalt Roll Roofing, Cap Sheets, and Shingles (D 228–42 T)[13]
EA–D 249a Asphalt Roofing Surfaced with Coarse Mineral Granules (D 249–42 T).[7]
EA–D 353 Insulated Wire and Cable: Performance Rubber Compound (D 353–41).[6]
EA–D 375 Test for Asbestos Roving for Electrical Purposes (D 375–42). (Specifications and Methods)[7]
EA–D 455 Milled Toilet Soap (D 455–39).[6]
EA–D 469a Insulated Wire and Cable: Heat-Resisting Rubber Compound (D 469–41).[13]
EA–D 496 Chip Soap (D 496–39)[13]
EA–D 498 Powdered Soap (Nonalkaline Soap Powder) (D 498–39)[13]
EA–D 499 White Floating Toilet Soap (D 499–39).[6]
EA–D 524 Test for Carbon Residue of Petroleum Products (Ramsbottom Carbon Residue) (D 524–42).[8]
EA–D 532a Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 532–39 T).[11]
EA–D 533 Built Soap, Powdered (D 533–41).[6]
EA–D 535 Palm Oil Solid Soap (Type A, Pure; Type B, Blended) (D 535–41).[6]
EA–D 536 Palm Oil Chip Soap (Type A, Pure; Type B, Blended) (D 536–42).[6]
EA–D 574 Insulated Wire and Cable: Ozone-Resistant Type Insulation (D 574–40 T).[6]
EA–D 592 Olive Oil Solid Soap (Type A, Pure; Type B, Blended) (D 592–42)
EA–D 593 Salt-Water Soap (D 593–42).[6]
EA–D 607 Mica Pigment (D 607–42).[8]
EA–D 630 Olive Oil Chip Soap (Type A, Pure; Type B, Blended) (D 630–42).[6]

INDEX TO ADVERTISERS

American Instrument Co. ... 65
Atlas Electric Devices Co. ... 65
Baldwin Southwark Corp. ... Inside Front Cover
Bausch & Lomb Optical Co. ... Outside Back Cover
Buehler, Adolph I. ... 71
Carver, Fred S. ... 70
Central Scientific Co. ... 68
Corning Glass Works ... 73
Dietert Co., Harry W. ... 66
Eimer & Amend, Inc. ... 67
Fish-Schurman Corp. ... 72
Fisher Scientific Co. ... 67
Greiner Co., The Emil ... 74
Kelley-Koett Mfg. Co., The ... 76
Kewaunee Mfg. Co. ... 66
Kimble Glass Co. ... 8
Lancaster Iron Works, Inc. ... 7
Leeds & Northrup Co. ... 64
Morehouse Machine Co. ... 67
Olsen Testing Machine Co., Tinius ... Inside Back Cover
Perkins & Son Co., B. F. ... 72
Picker X-ray Corp. ... 3–6
Reinhold Publishing Corp., The ... 72
Riehle Testing Machine Division, American Machine & Metals, Inc. ... 2
Sargent & Co., E. H. ... 68
Schleicher & Schuell Co., Carl ... 66
Spencer Lens Co. ... 75
Taber Instrument Corp. ... 74
Thomas Co., Arthur H. ... 64
Wilkens-Anderson Co. ... 69
Wilson Mechanical Instrument Co., Inc. ... 72
Professional Cards ... 63